Structural evolution of galaxies since cosmic noon

Stijn Wuyts

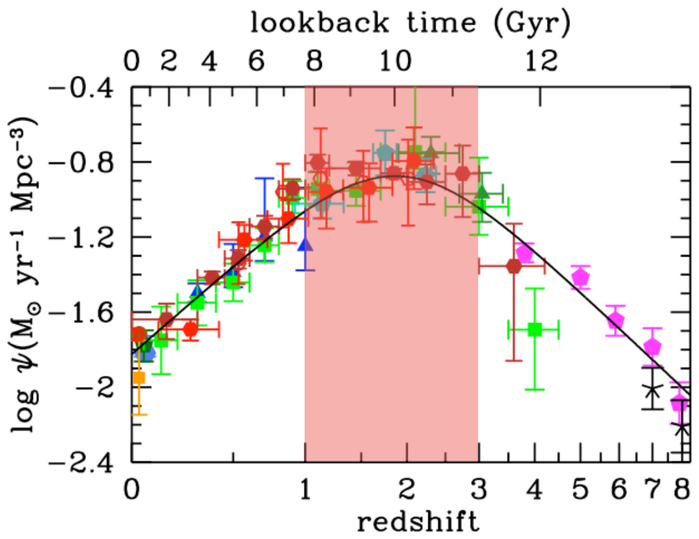
Charlotte Avery, Natascha Förster Schreiber, Kay Guo, Shardha Jogee, Amit Nestor,
Pascal Oesch, Sedona Price, Raman Sharma, Kenichi Tadaki, Jun Toshikawa, Junkai Zhang
KMOS3D, 3D-DASH, CEERS, FRESCO teams

UNIVERSITY OF BATH

ESAC, October 2022

JWST pushing
- sensitivity
- resolution
- λ-range

Pre-JWST/Euclid observational landscape
— two decades of lookback surveys



Madau & Dickinson 2014, ARAA

Euclid Grism

Euclid imaging

Spectral resolution

Sample size at 1<z<3

10^4
10^3
10^2
10

10^2 10^3 10^4 10^5 10^6

DEEP2
NIR-IFUs
MOSDEF
KBSS-MOSFIRE
NIR-IFUs
FMOS-COSMOS
TKRS2
zFIRE
FastSound
DEEP3
GOODS-N
KBSS-UV
BM/BX/
LBG
zCOSMOS
VANDELS
CDFS
VVDS
3D-HST/
AGHAST
VUDS
GLASS
WISPs

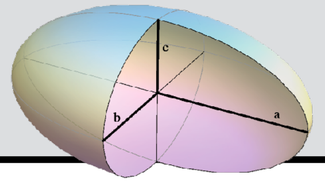
1 < z < 3 galaxies
Unlensed
Lensed

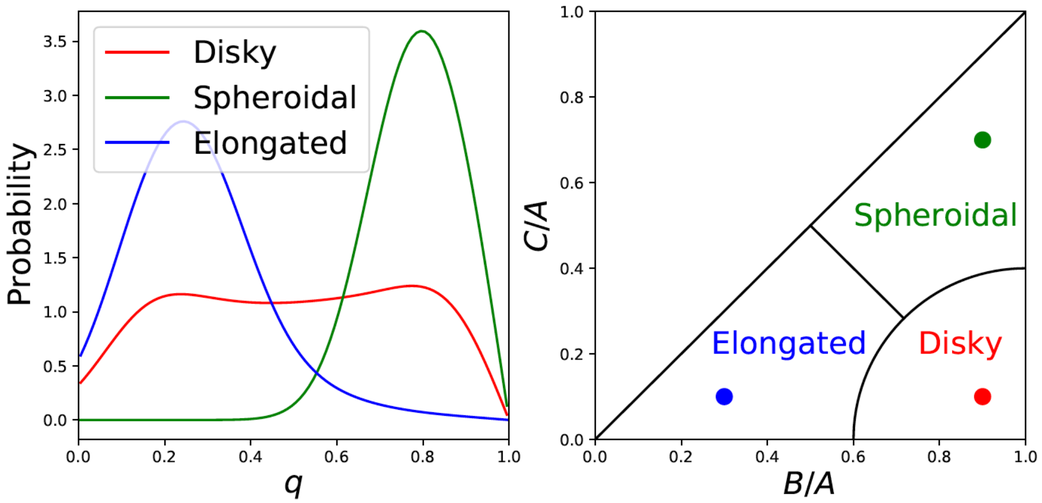
Phot
Phot + HST imaging
Grism
Opt spectro
NIR spectro
NIR IFU

MUSYC-ECDFS
MUSYC-ECDFS-MB
COSMOS-MB
HSC-UD
zFOURGE-MB
zFOURGE
HSC-D
KV450
AEGIS-MB
AEGIS
CANDELS
COSMOS
HFF-μ > 10
HFF-μ > 2
BM/BX/
LBG
HFF
HSC-W

Förster Schreiber & Wuyts 2020, ARAA

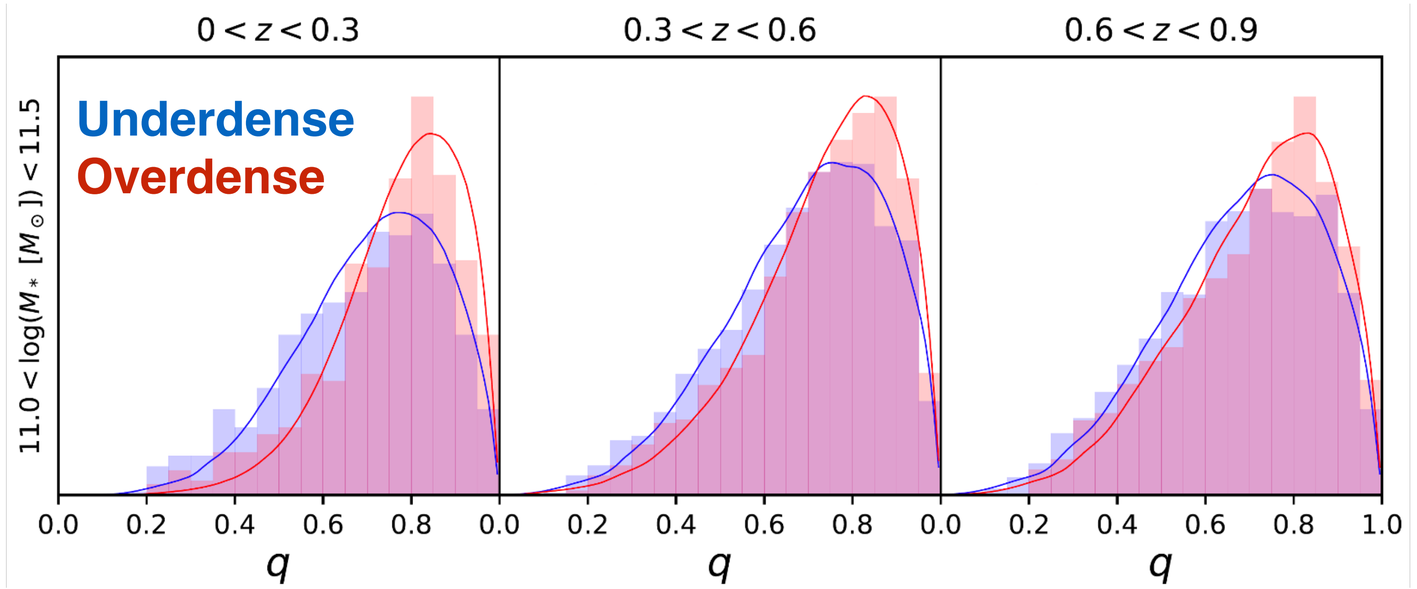
Intrinsic 3D shapes - quiescent galaxies





Projected axis ratio

Intrinsic axis ratios



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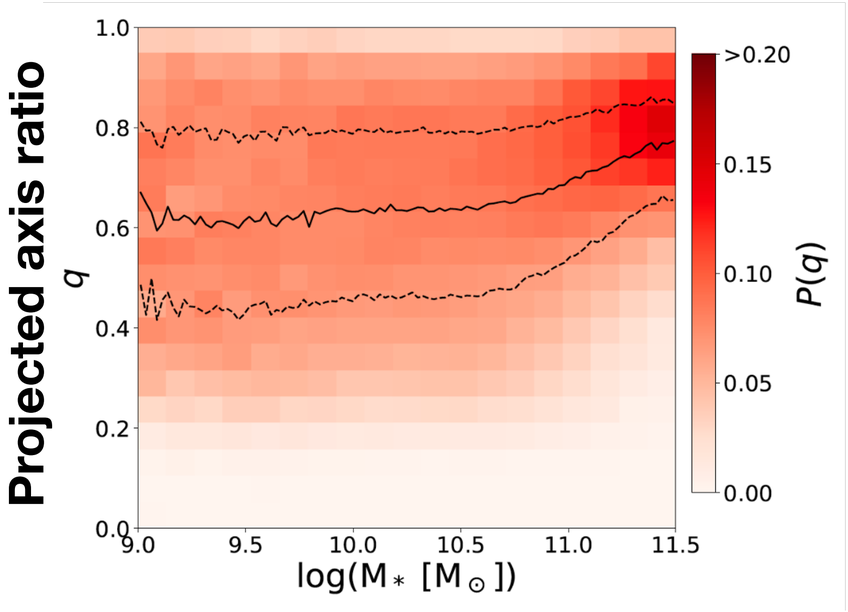


Over last half of cosmic history, quiescent galaxies have:

Rounder 3D shapes at the high-mass end

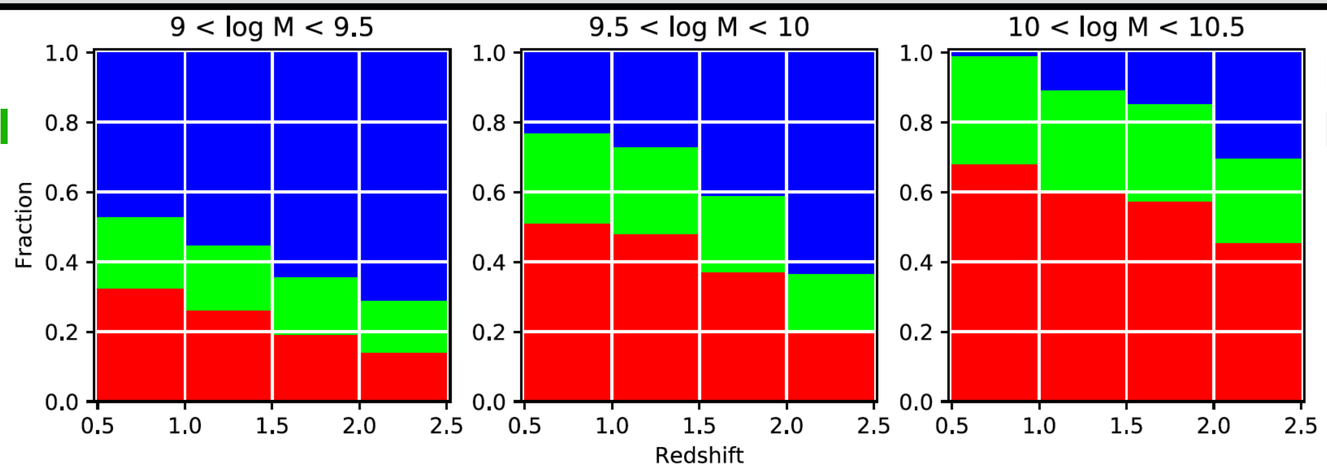
Especially in overdense environments

$n_{Sersic} \geq 4$ QGs are spheroidal in 3D at any mass

Zhang,SW+2022 **KiDS+VIKING+HSC-SSP (500,000 quiescent galaxies at 0<z<0.9)** also van der Wel+2009; Holden+2012; Satoh+2019

Intrinsic 3D shapes - star-forming galaxies

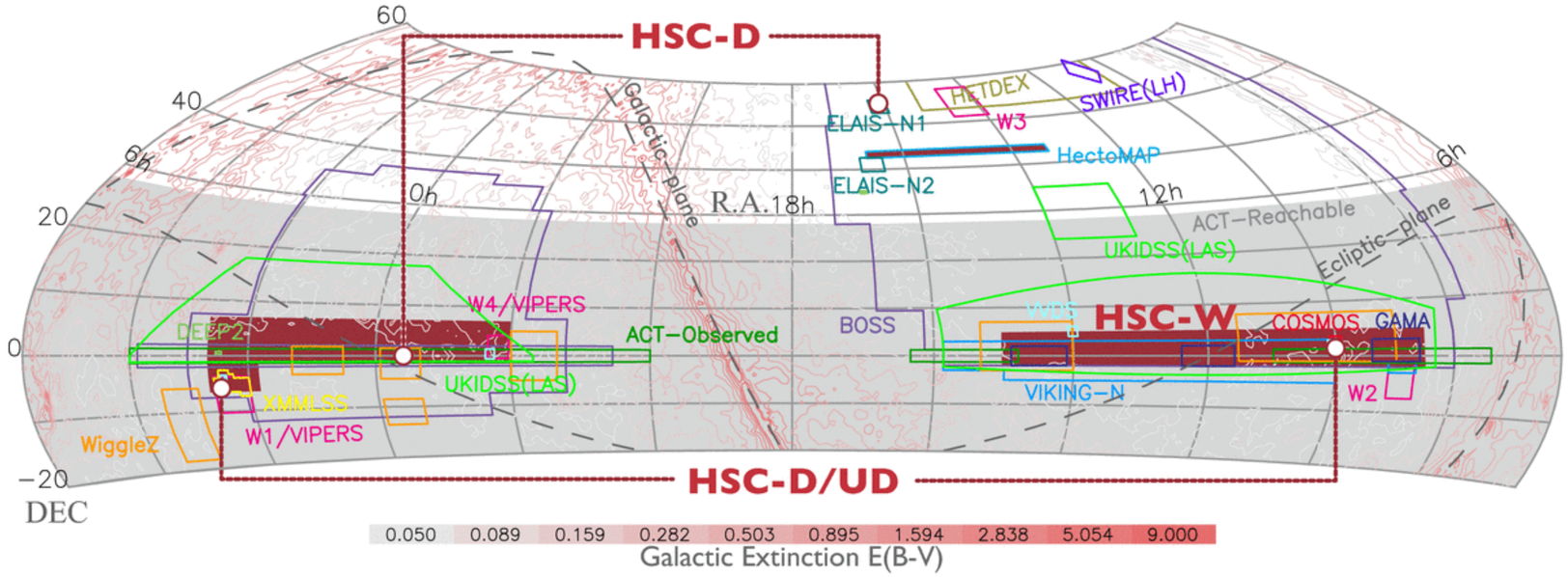
Elongated
Spheroidal
Disky

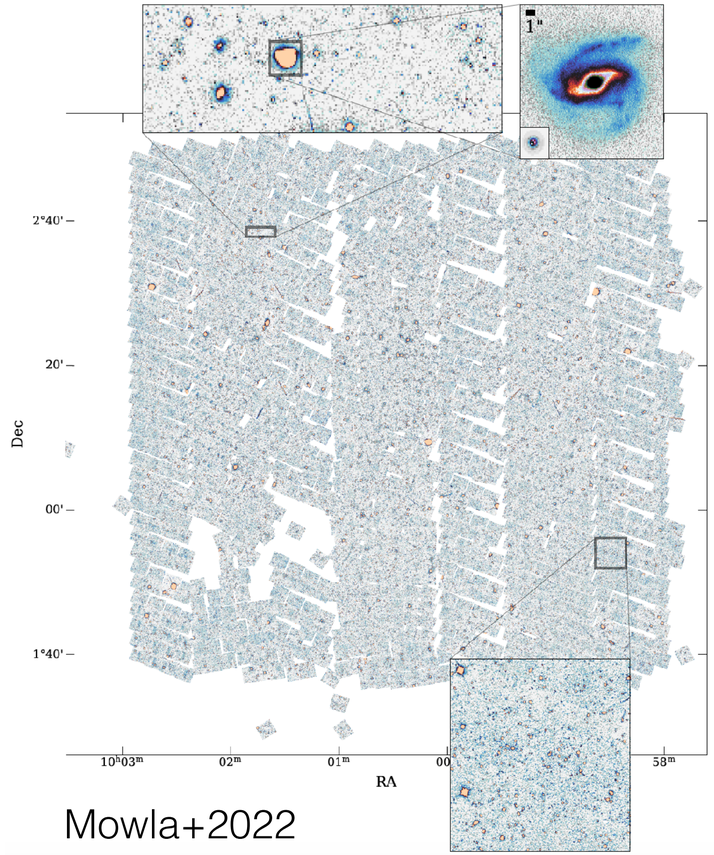


Elongated shapes at low-M & high-z
Disky shapes at intermediate M

Zhang+2019 **CANDELS**
also Elmegreen+2005; Law+2012; van der Wel+2014

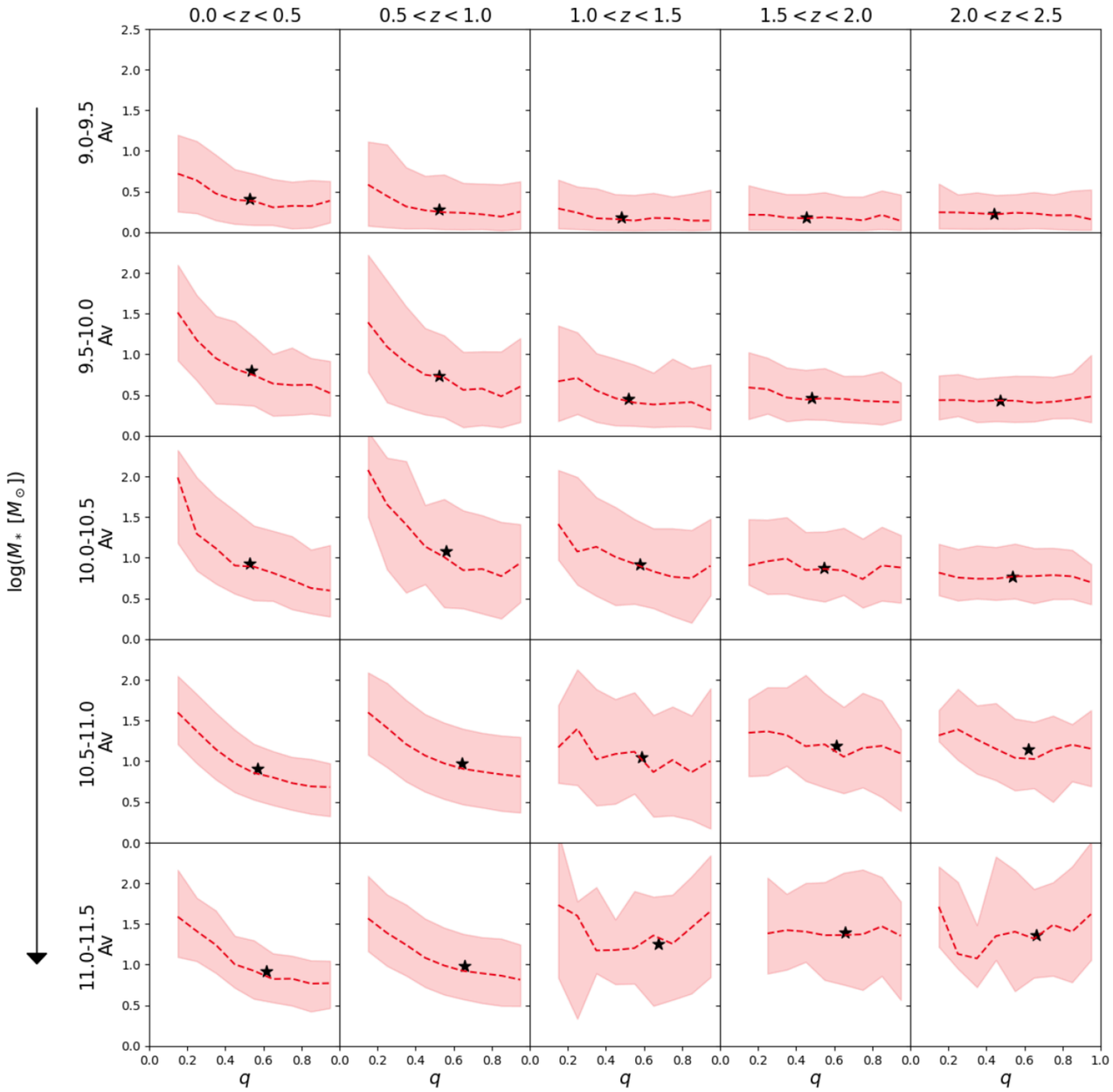
Rounder shapes at log(M) > 11 & low-z
Zhang+in prep **HSC + 3D-DASH**





Mowla+2022

Inclination-dependent attenuation



Attenuation vs projected axial ratio

★ **median A_V for (M_{star}, z) bin**

- @fixed M: stronger A_V — q relation at lower redshift
- Typical A_V increases with increasing M
- @fixed M:
  typical A_V varies only modestly with z

Zhang+in prep **CANDELS, 3D-DASH, KiDS + VIKING + HSC-SSP**
also Patel+2012; Zuckerman+2021; Shapley+2022

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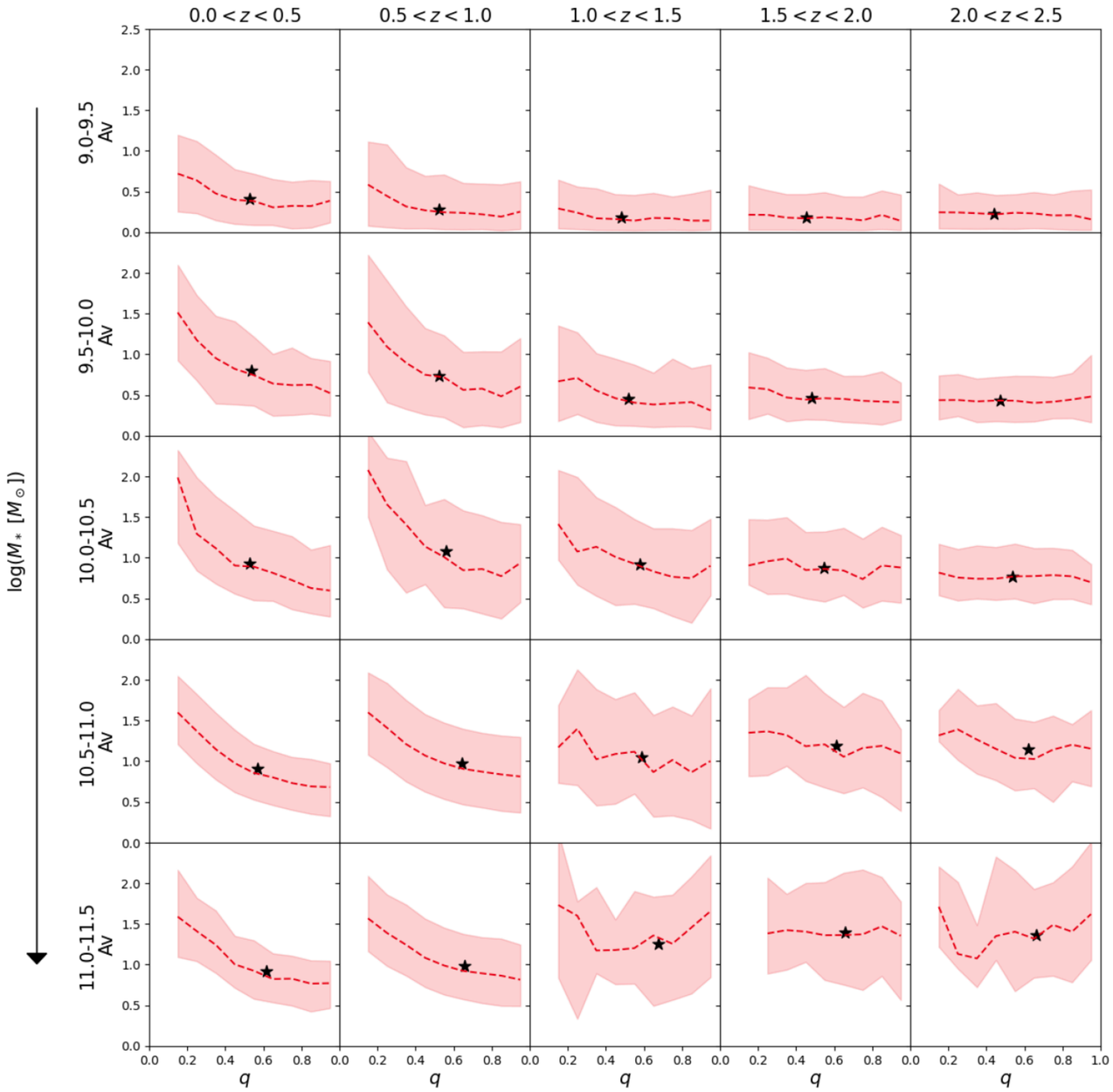

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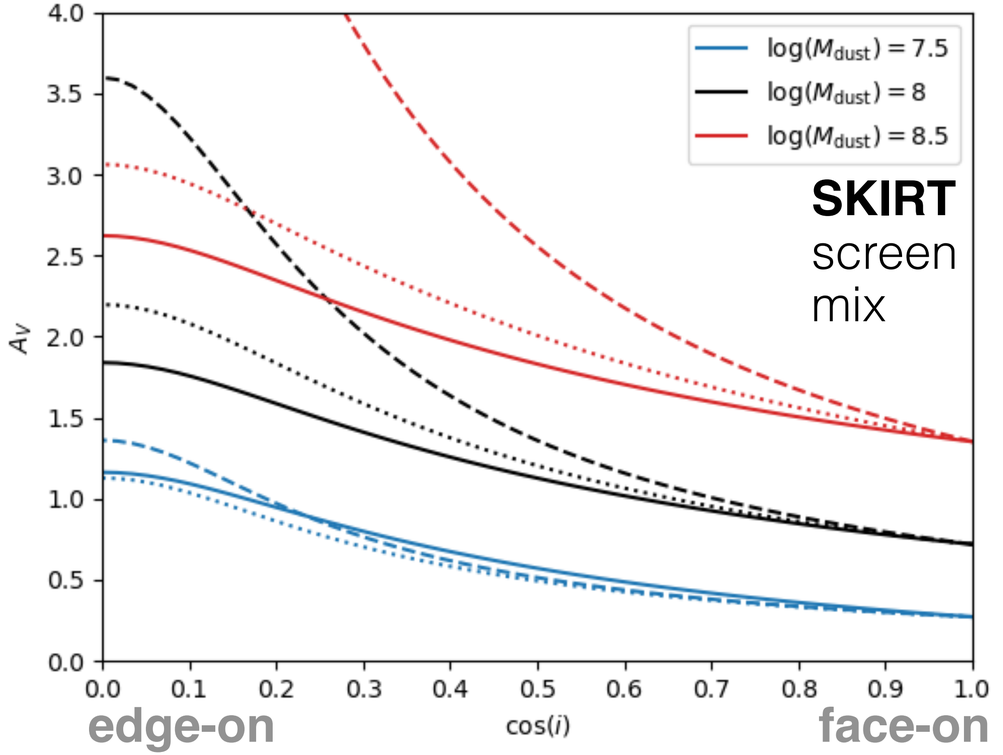
Radiative transfer on smooth
toy model ellipsoidal galaxy
with $R_{dust} = R_{star}$ and Sersic radial profile



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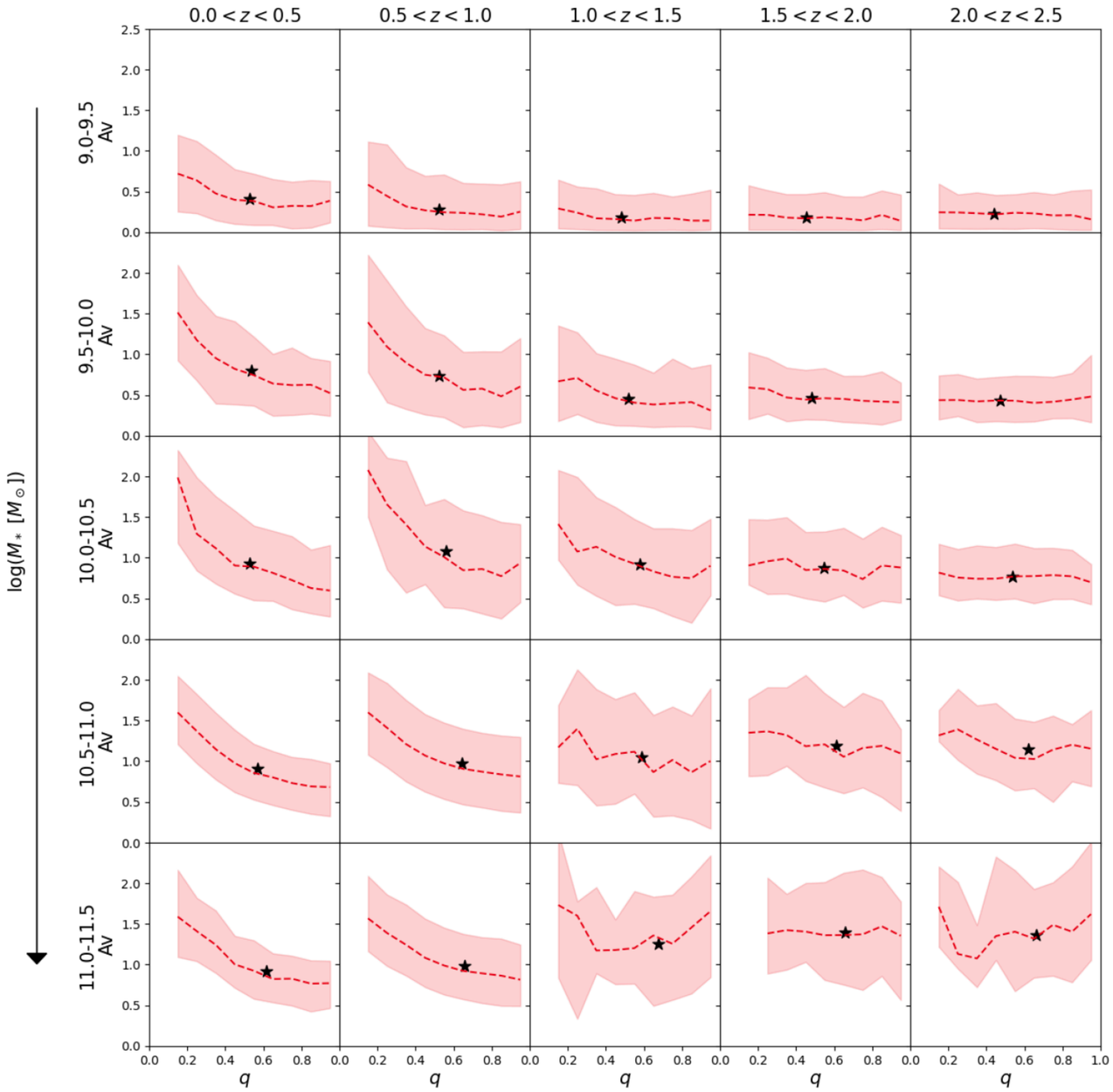

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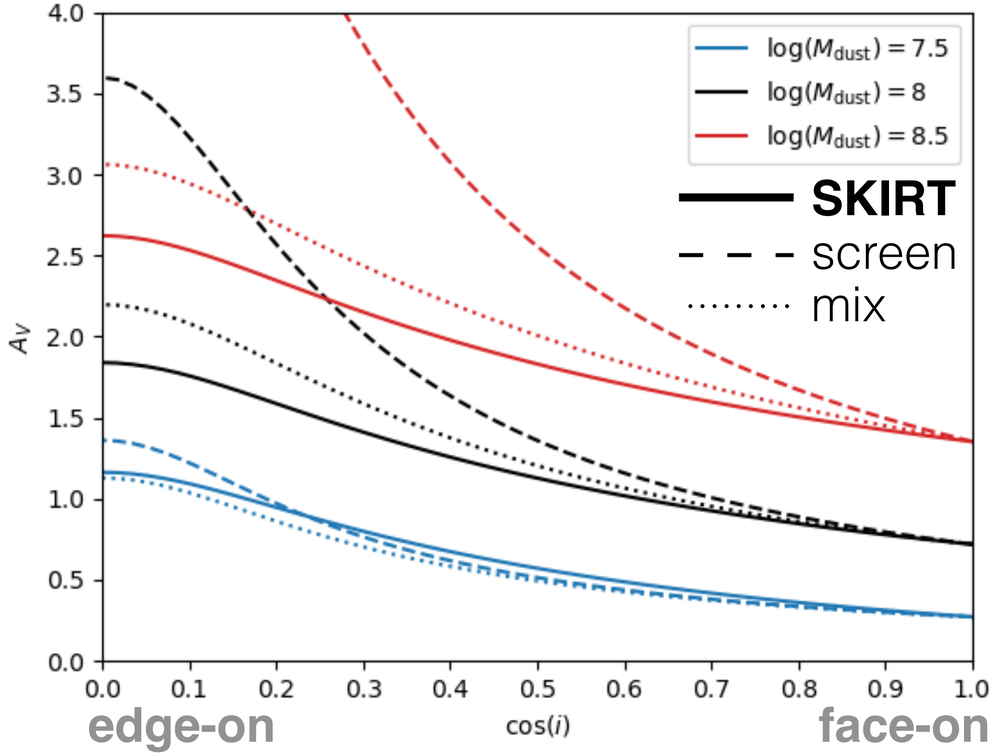

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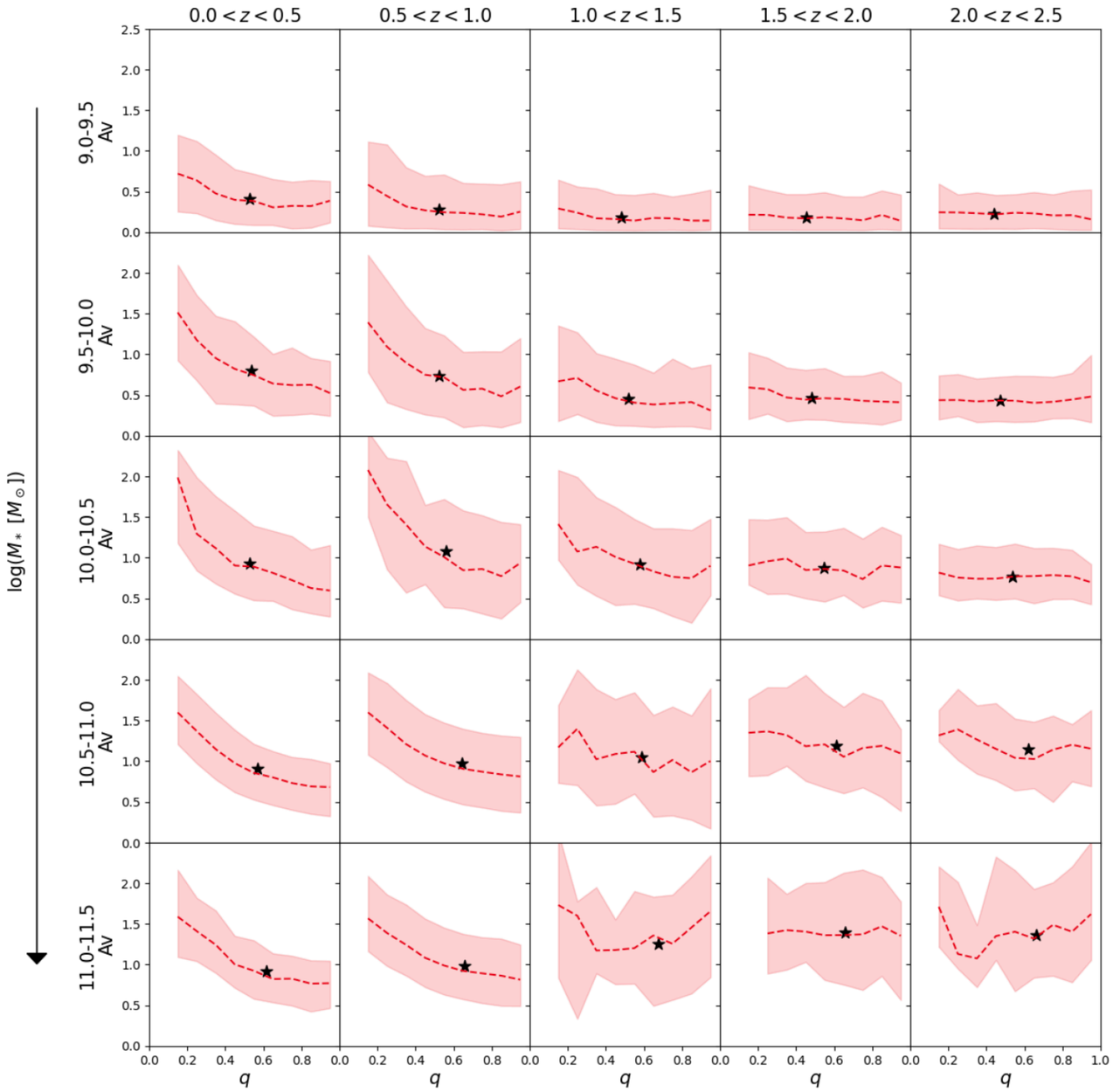

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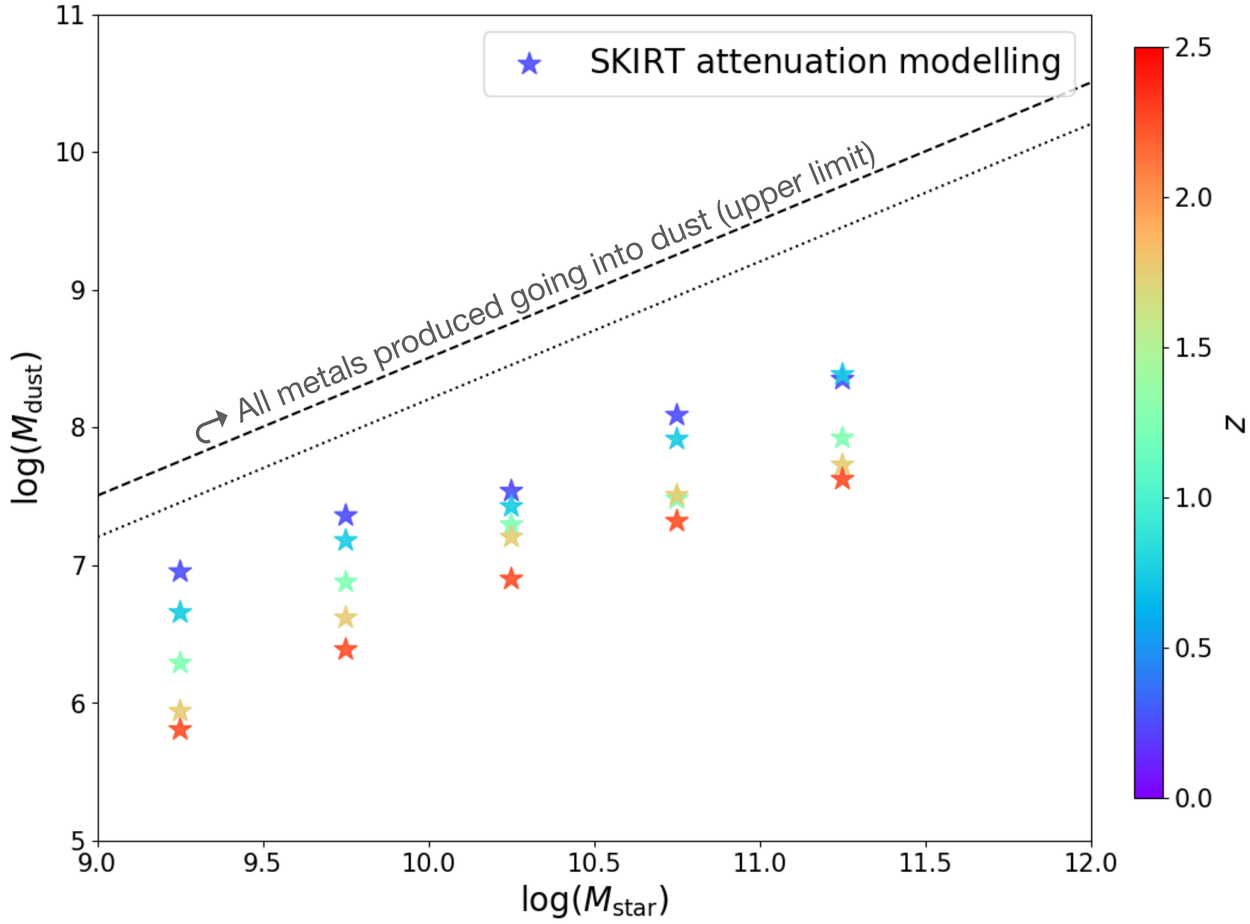

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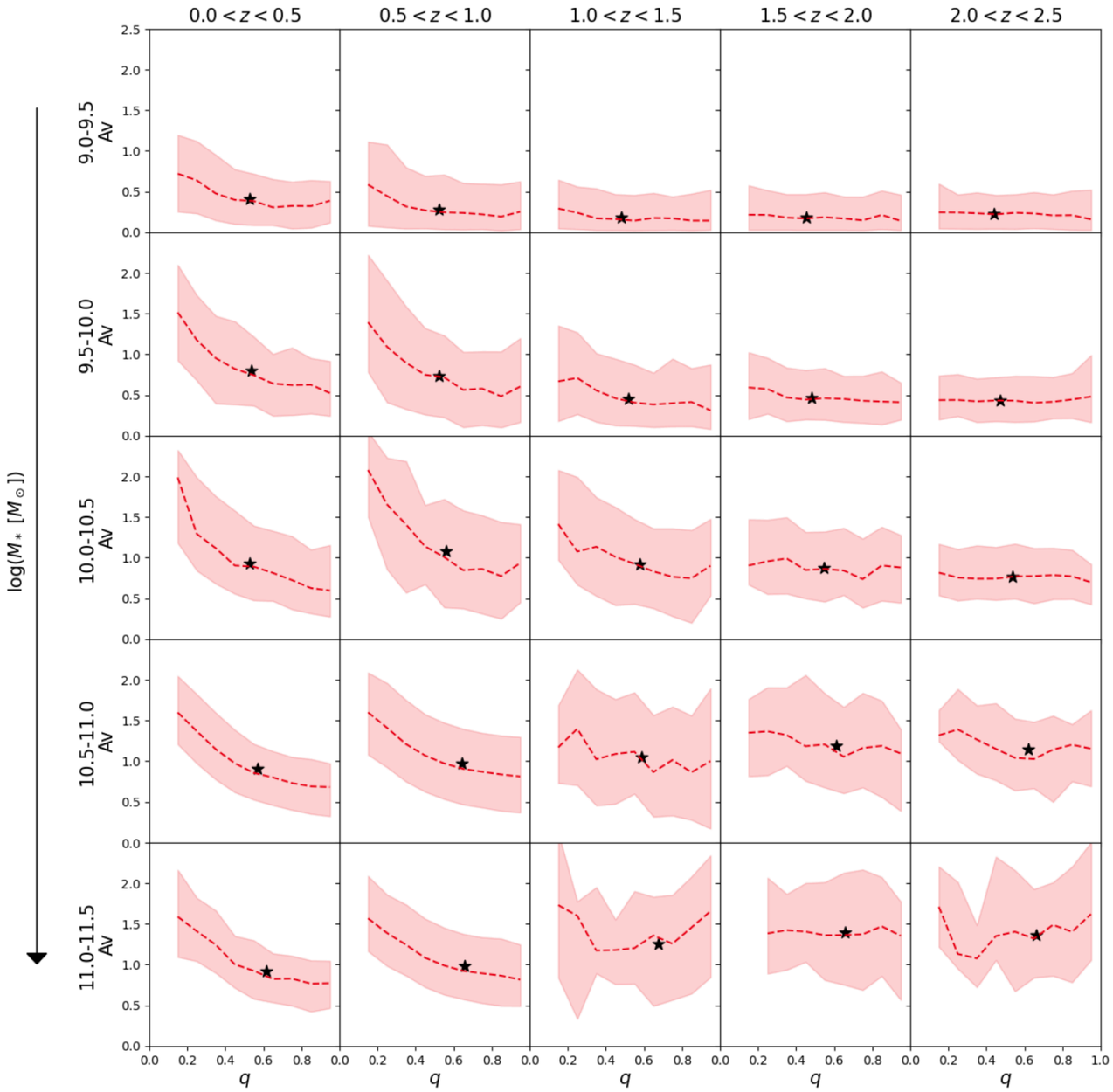

Attenuation vs projected axial ratio

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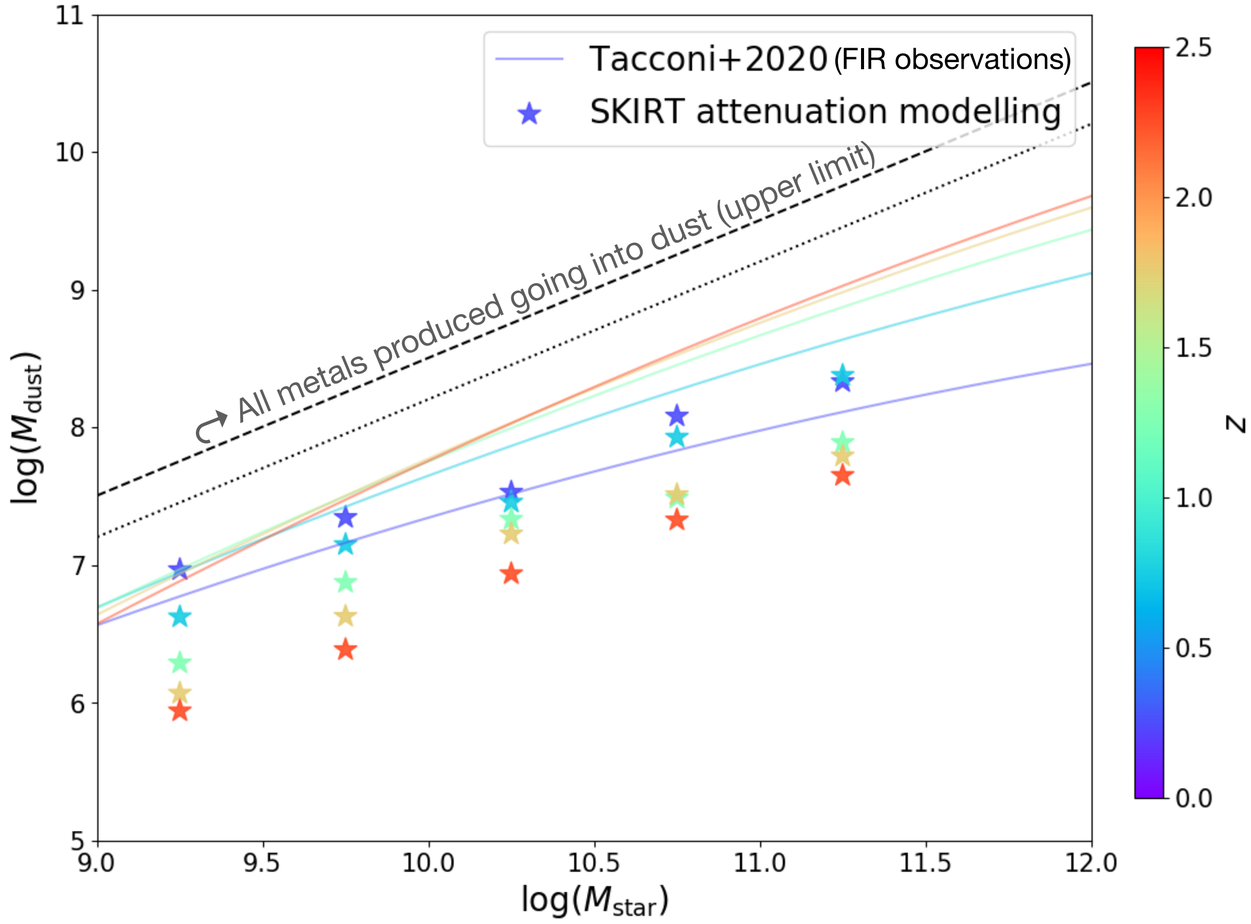

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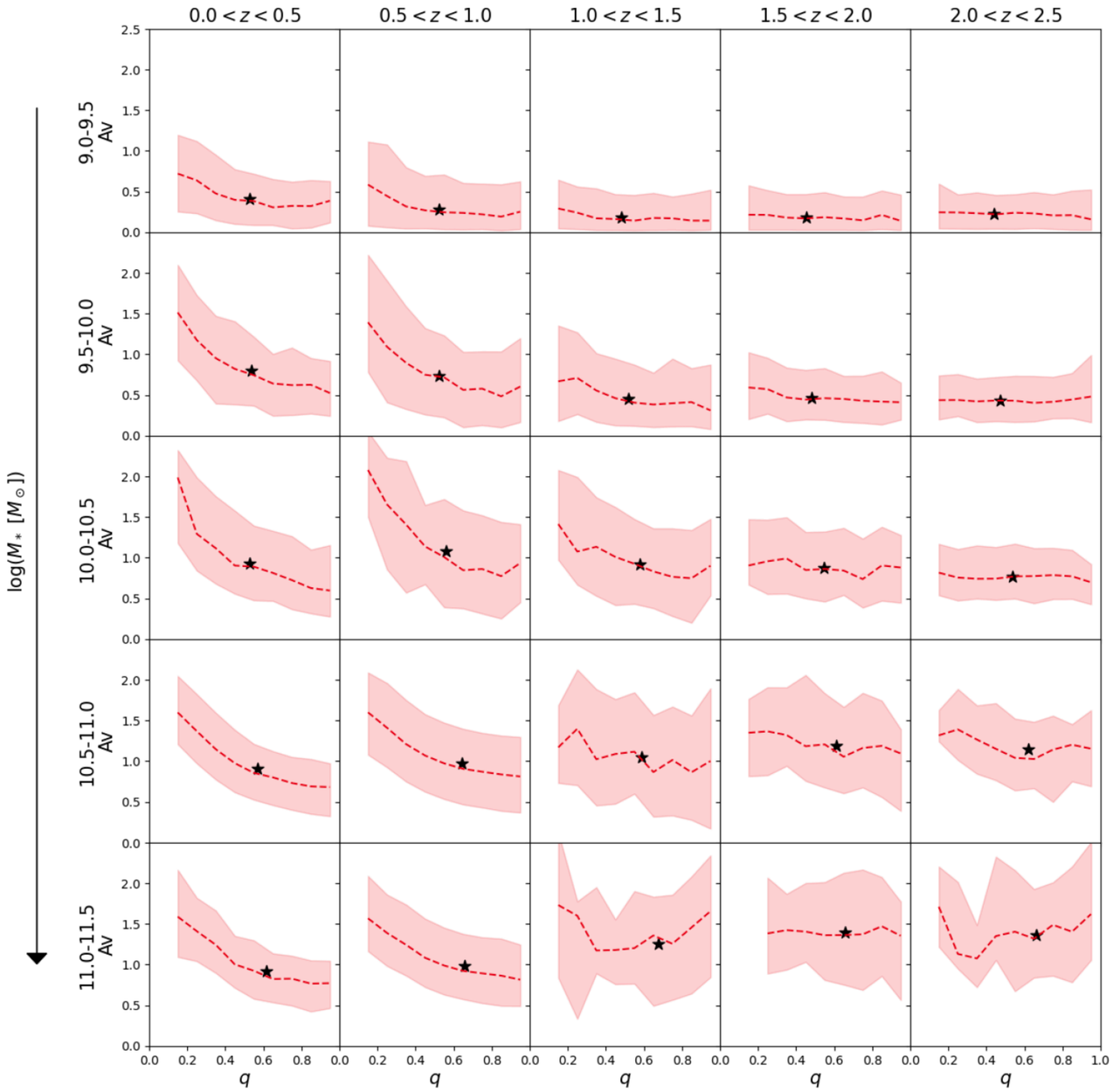

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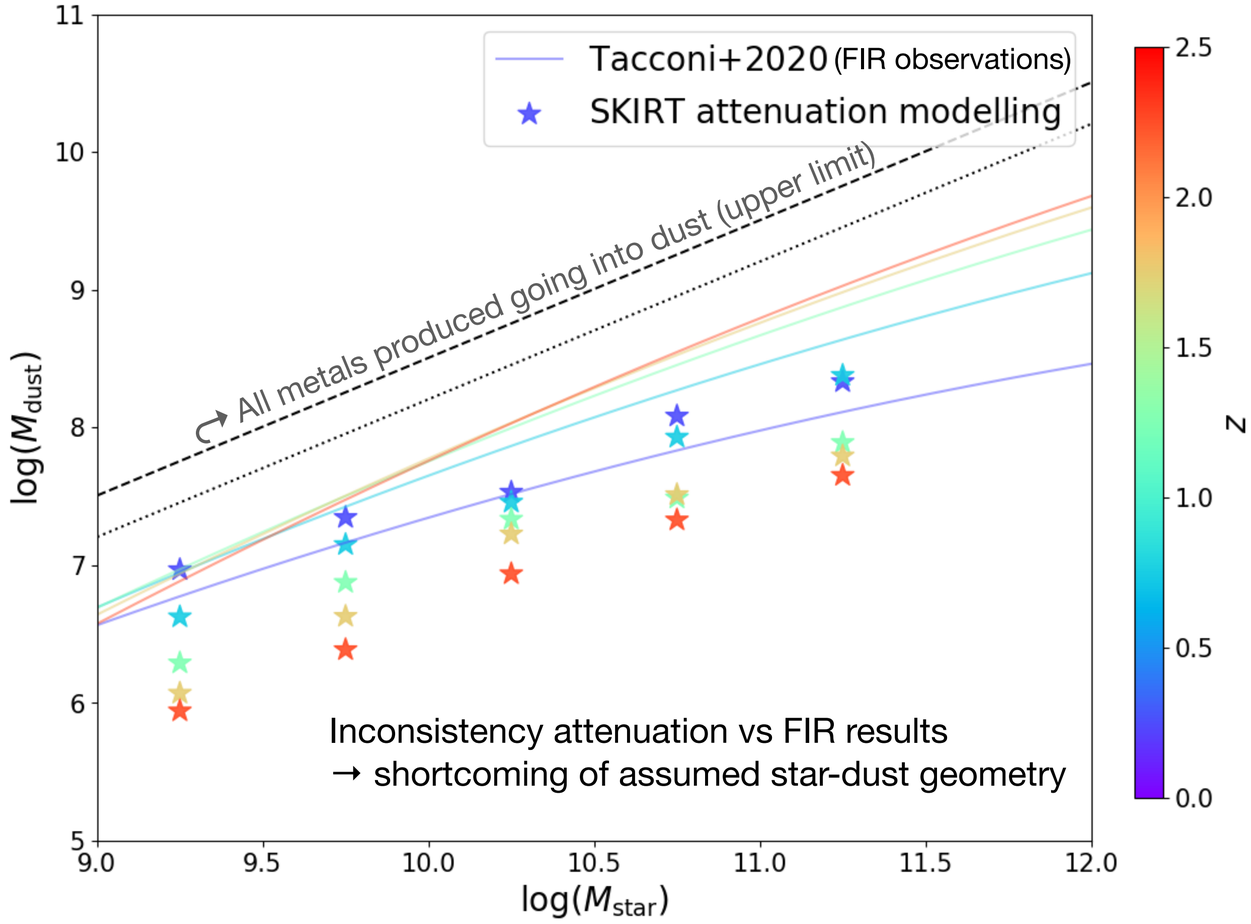

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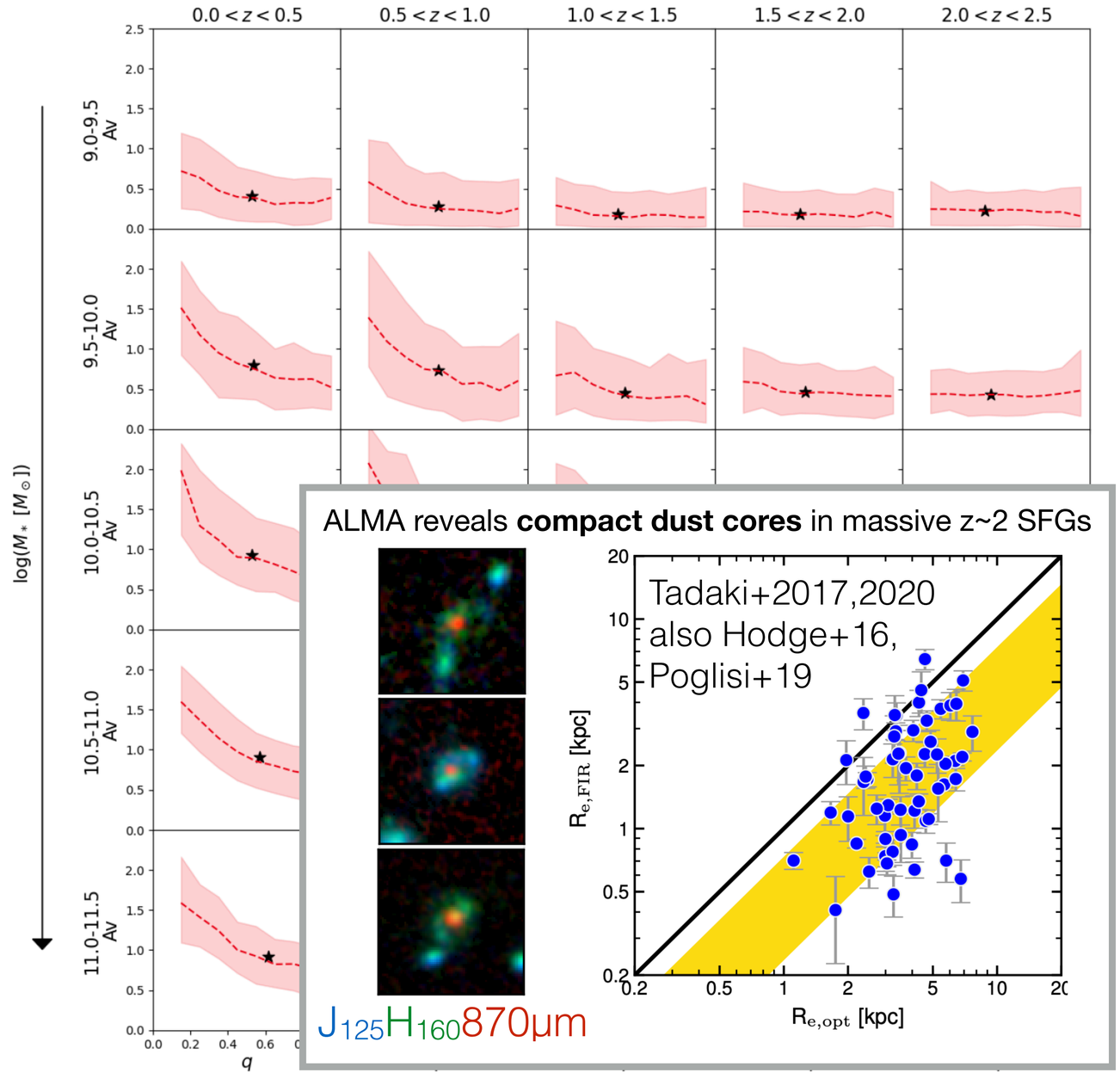
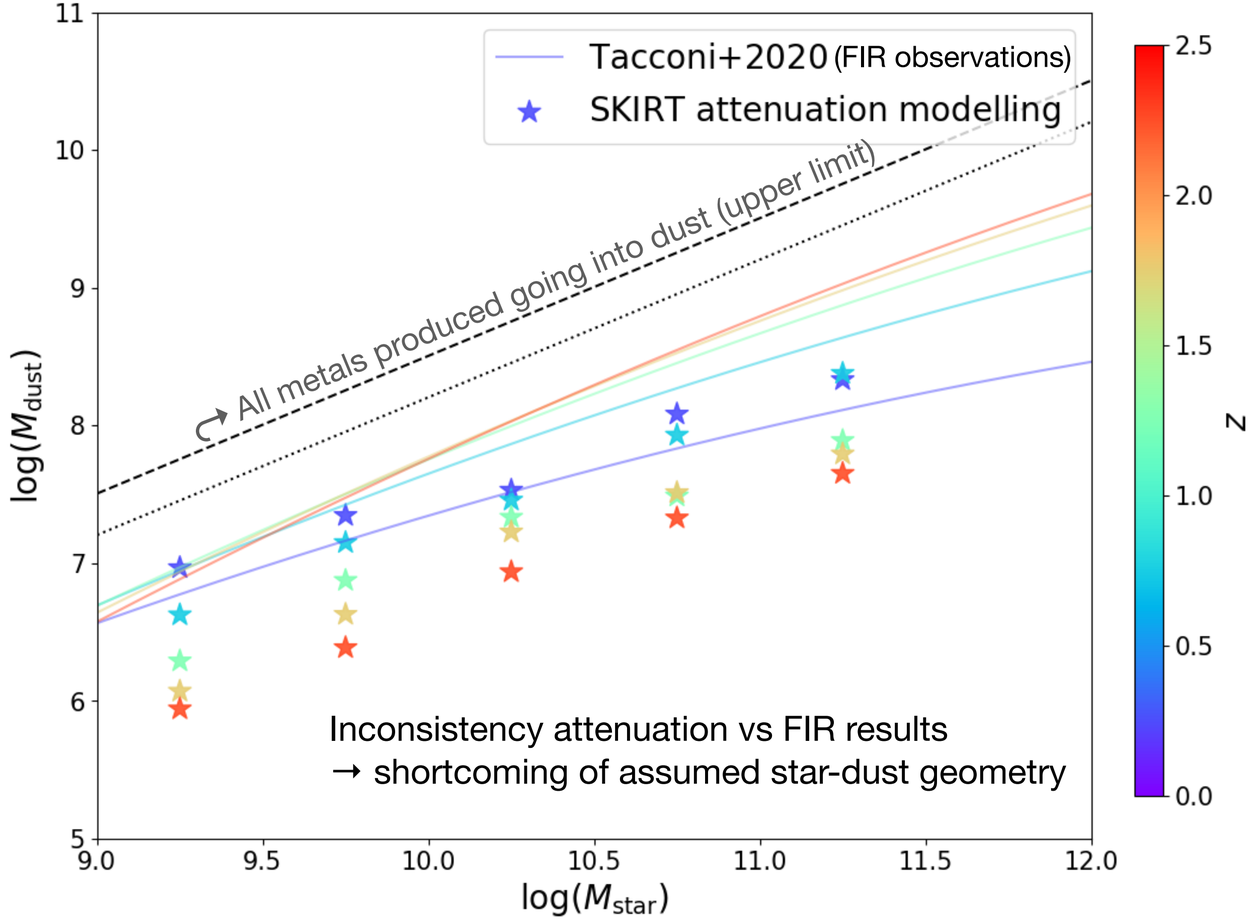


ALMA reveals **compact dust cores** in massive z~2 SFGs

J125H160870μm

Attenuation vs projected axial ratio

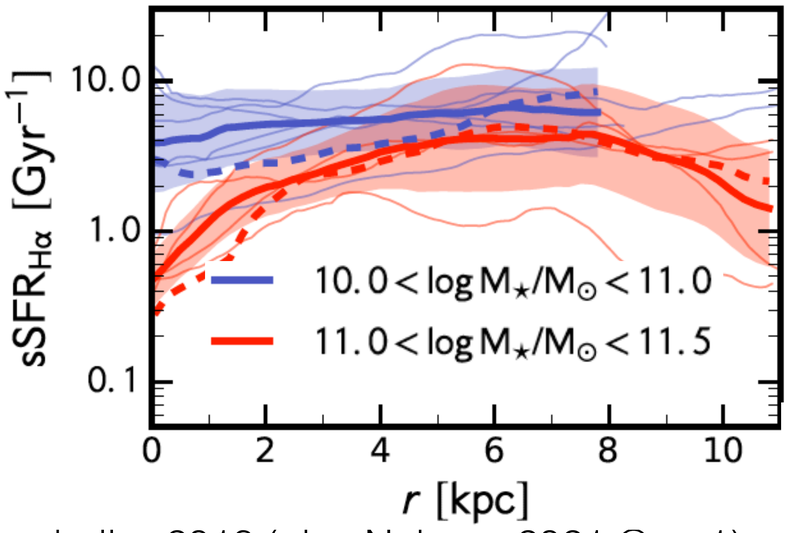
★ **median A_V for (M_{star}, z) bin**



Zhang+in prep **CANDELS, 3D-DASH, KiDS + VIKING + HSC-SSP**
also Patel+2012; Zuckerman+2021; Shapley+2022

ent attenuation

NIR-IFUs reveal **extended Hα disks** in massive z~2 SFGs
Even after best-effort dust correction



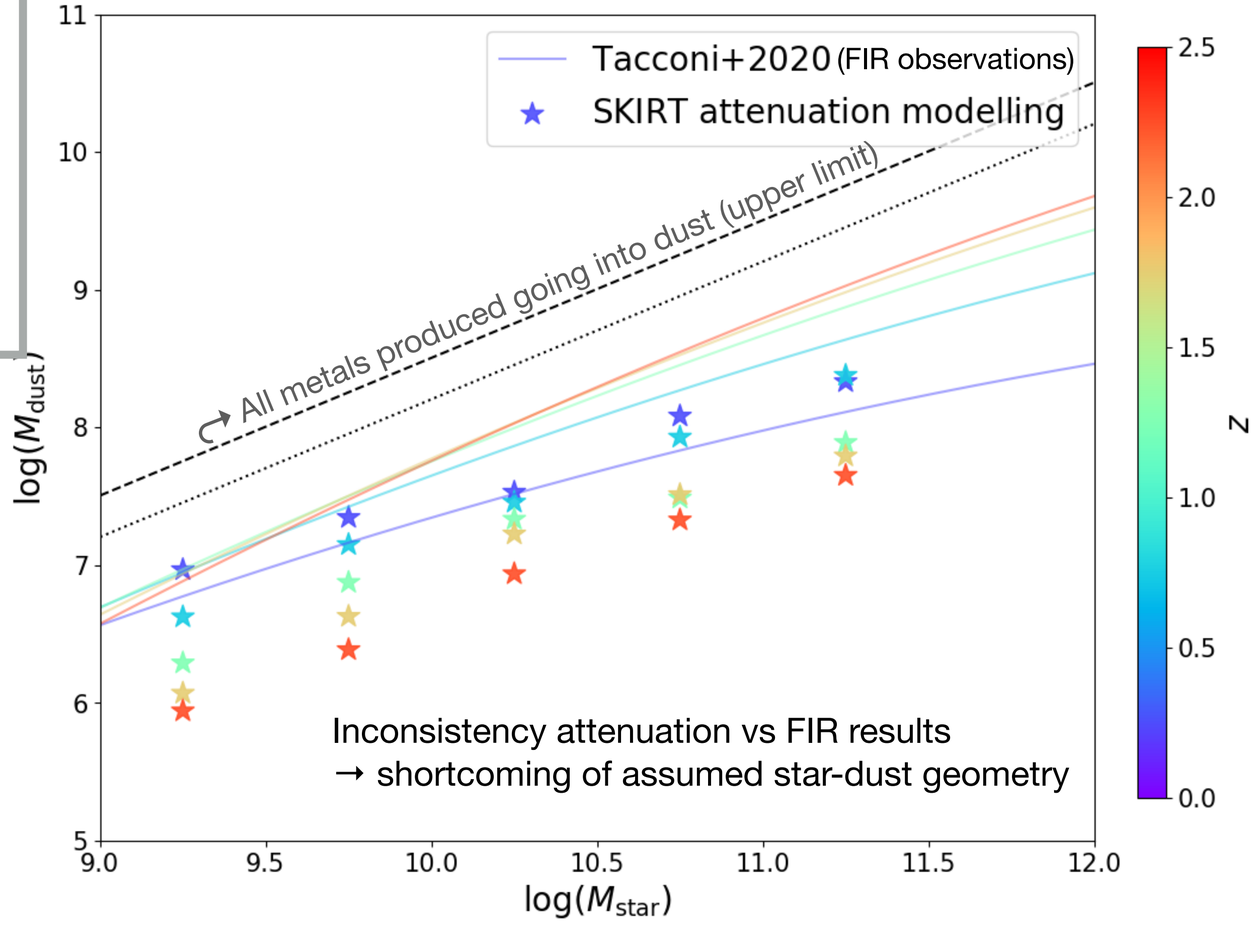
Tacchella+2018 (also Nelson+2021 @ z~1)

ALMA reveals **compact dust cores** in massive z~2 SFGs

J$_{125}$H$_{160}$870μm

ttenuation vs projected axial ratio

median A_V for (M_{star}, z) bin



Zhang+in prep **CANDELS, 3D-DASH, KiDS + VIKING + HSC-SSP**
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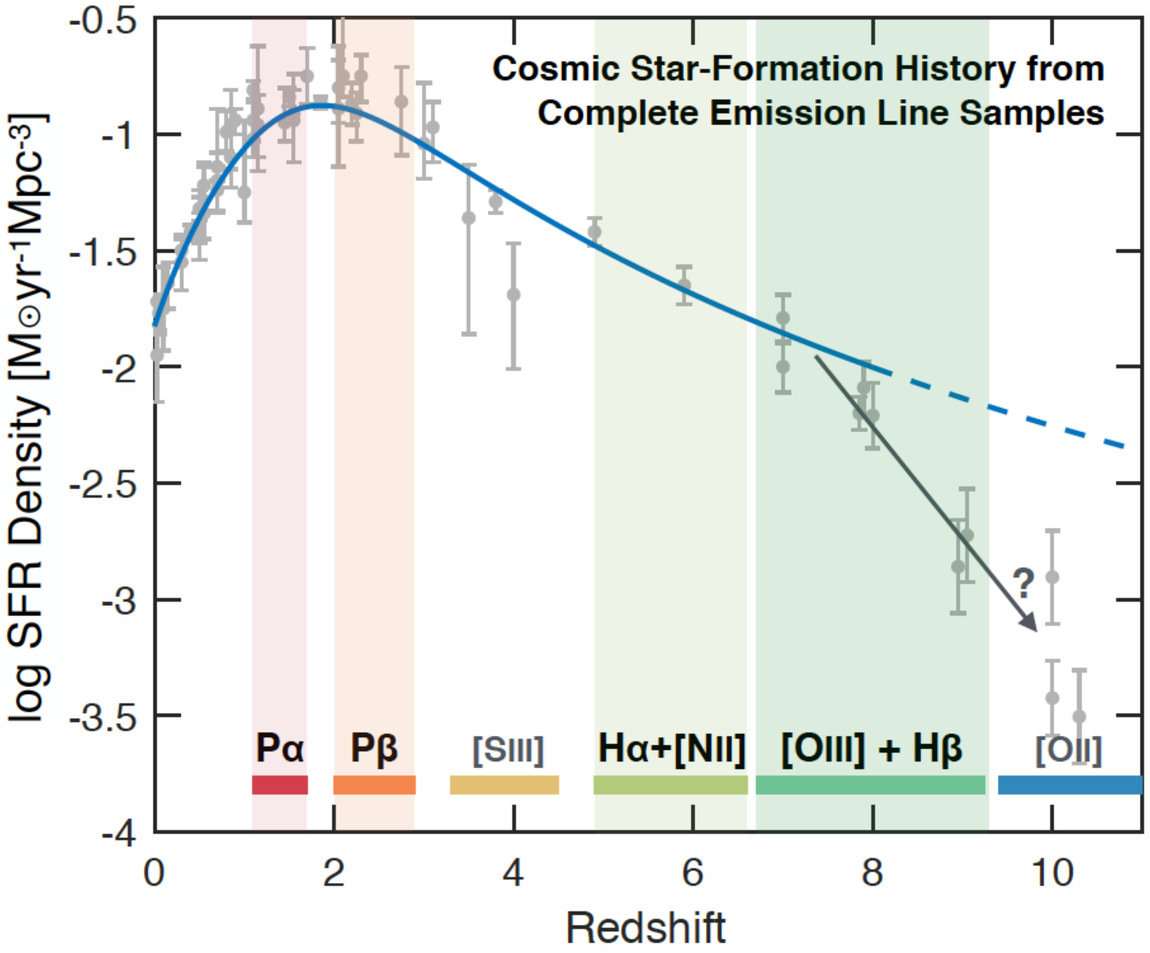
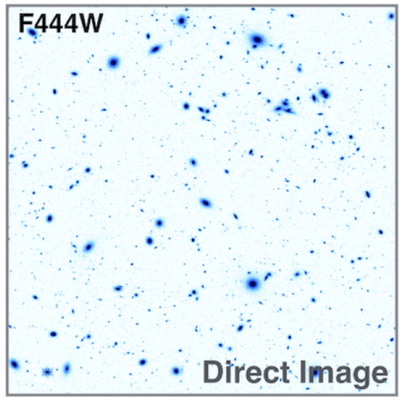
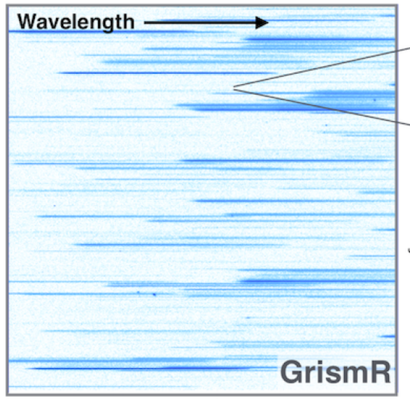
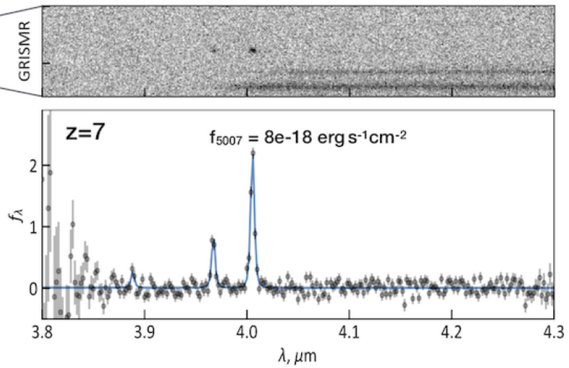
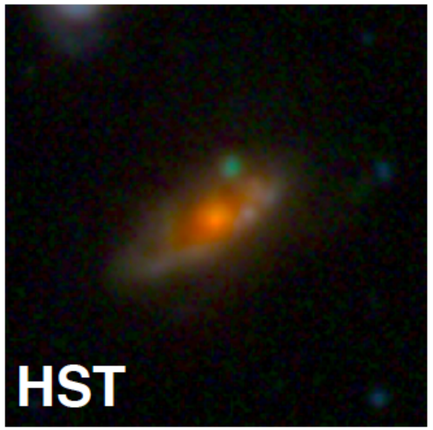
Outlook: FRESCO JWST/NIRCam

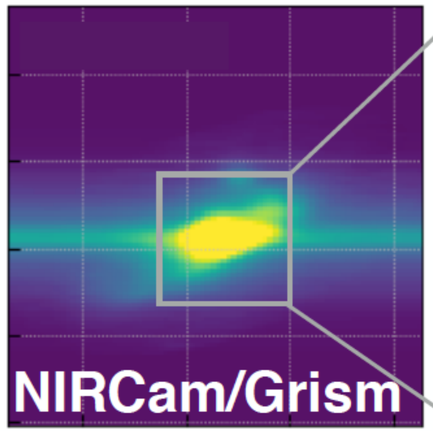


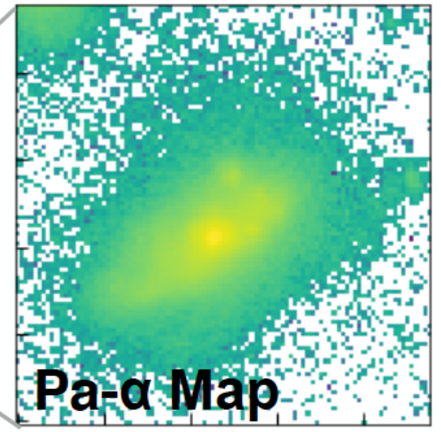








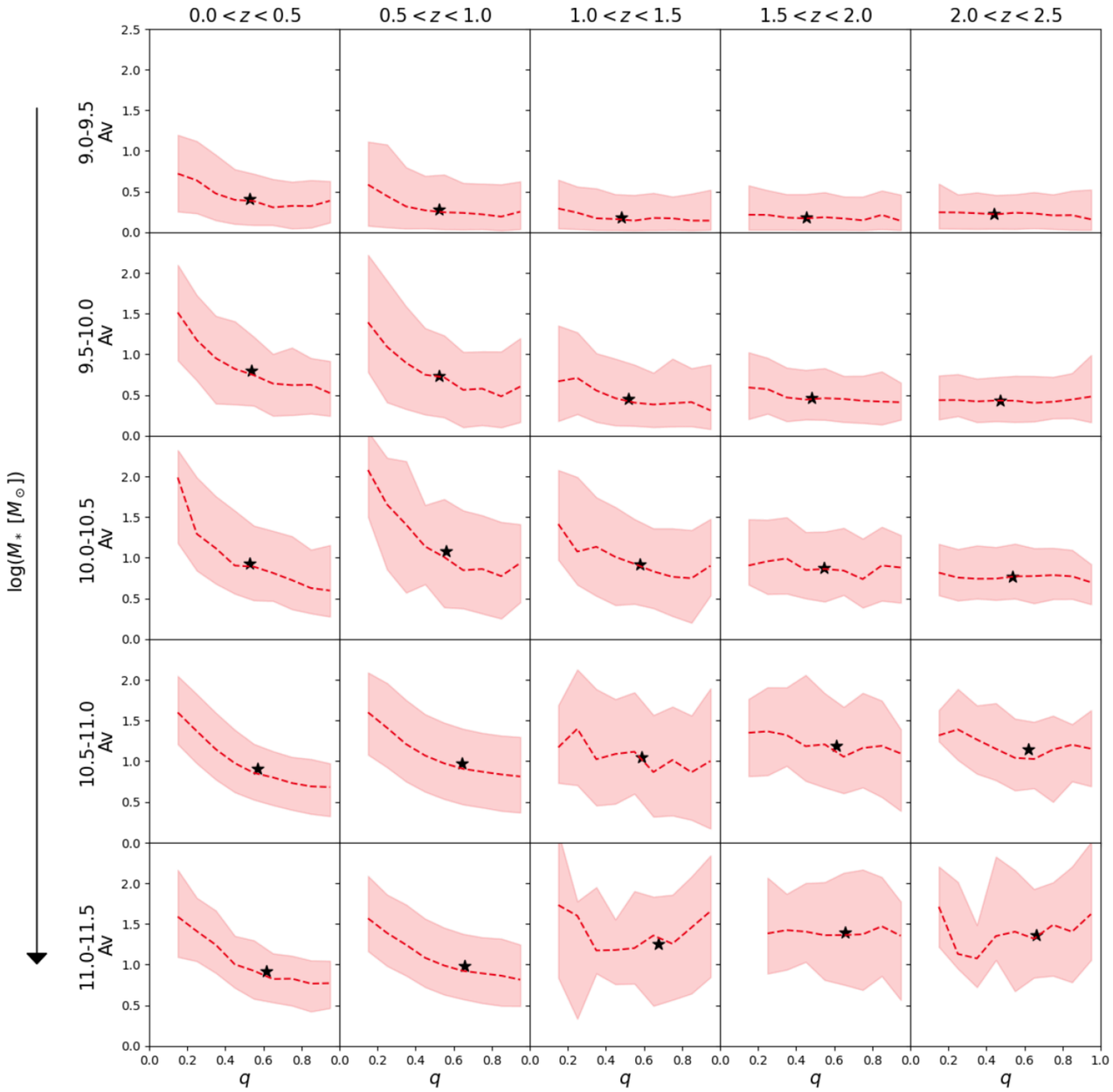




Dust-insensitive SFR tracers at cosmic noon

PI P.Oesch **FRESCO JWST/NIRCam grism**

Inclination-dependent attenuation



Attenuation vs projected axial ratio

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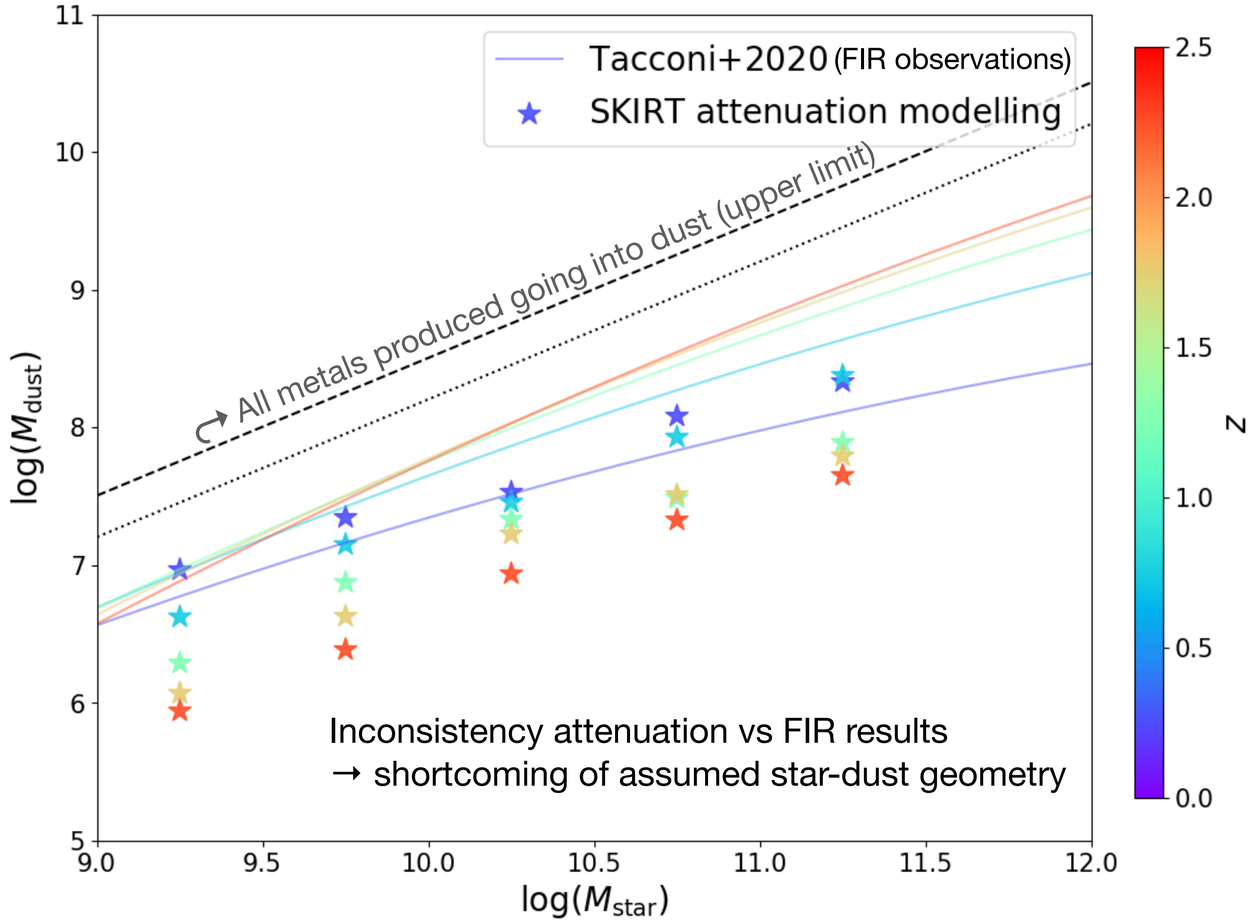

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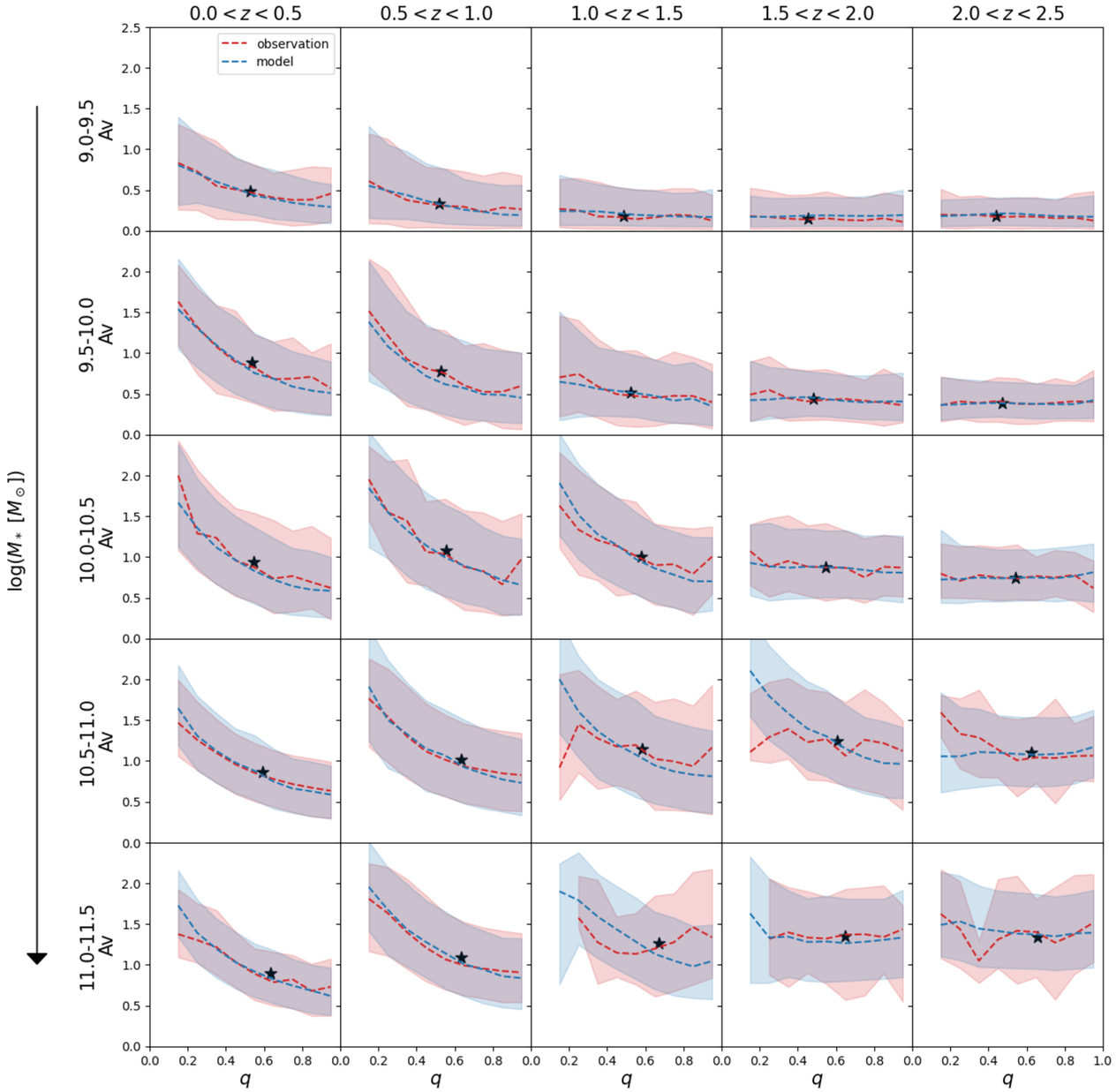
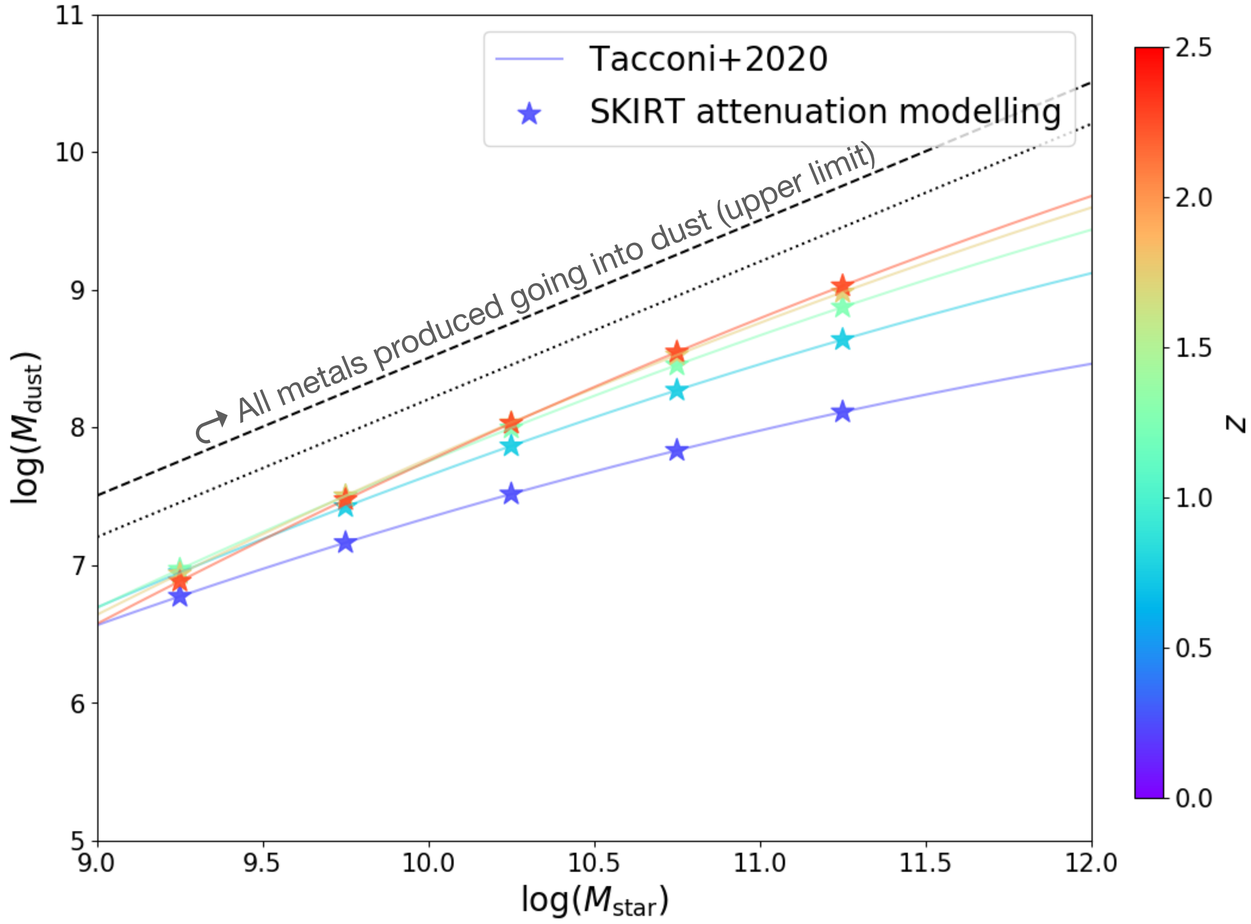
also Patel+2012; Zuckerman+2021; Shapley+2022

Star-dust geometries



Clumpier dust geometries in higher-z SFGs



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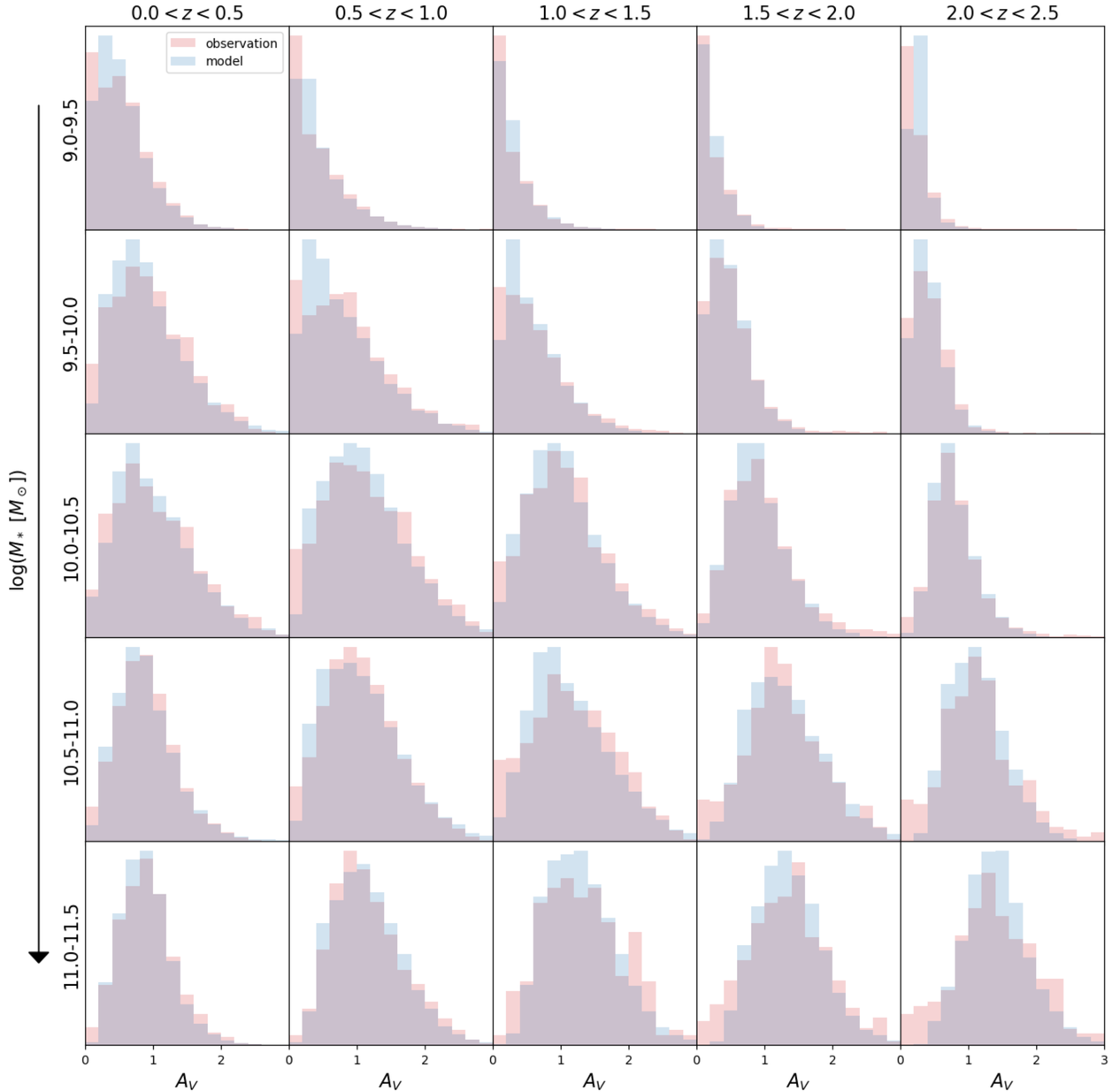

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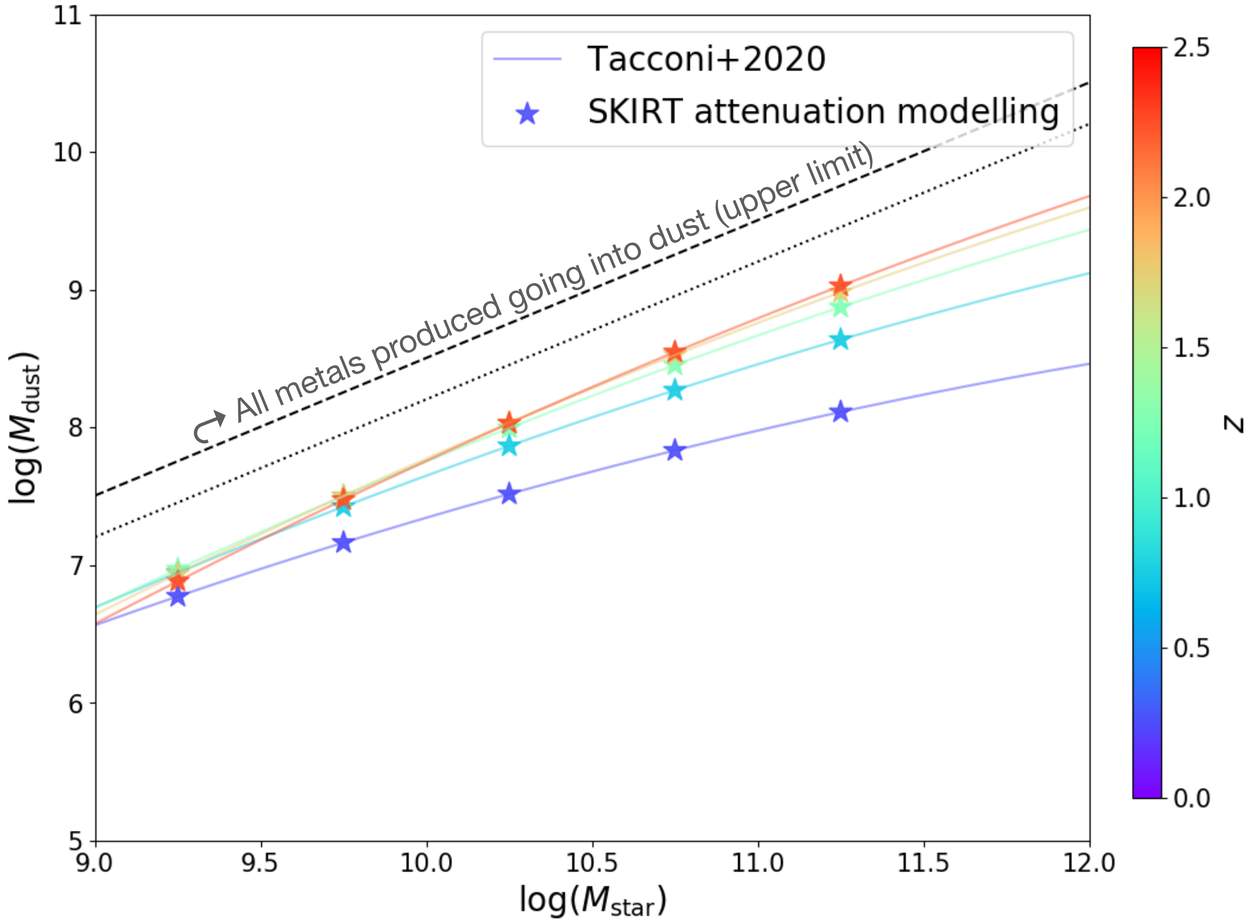

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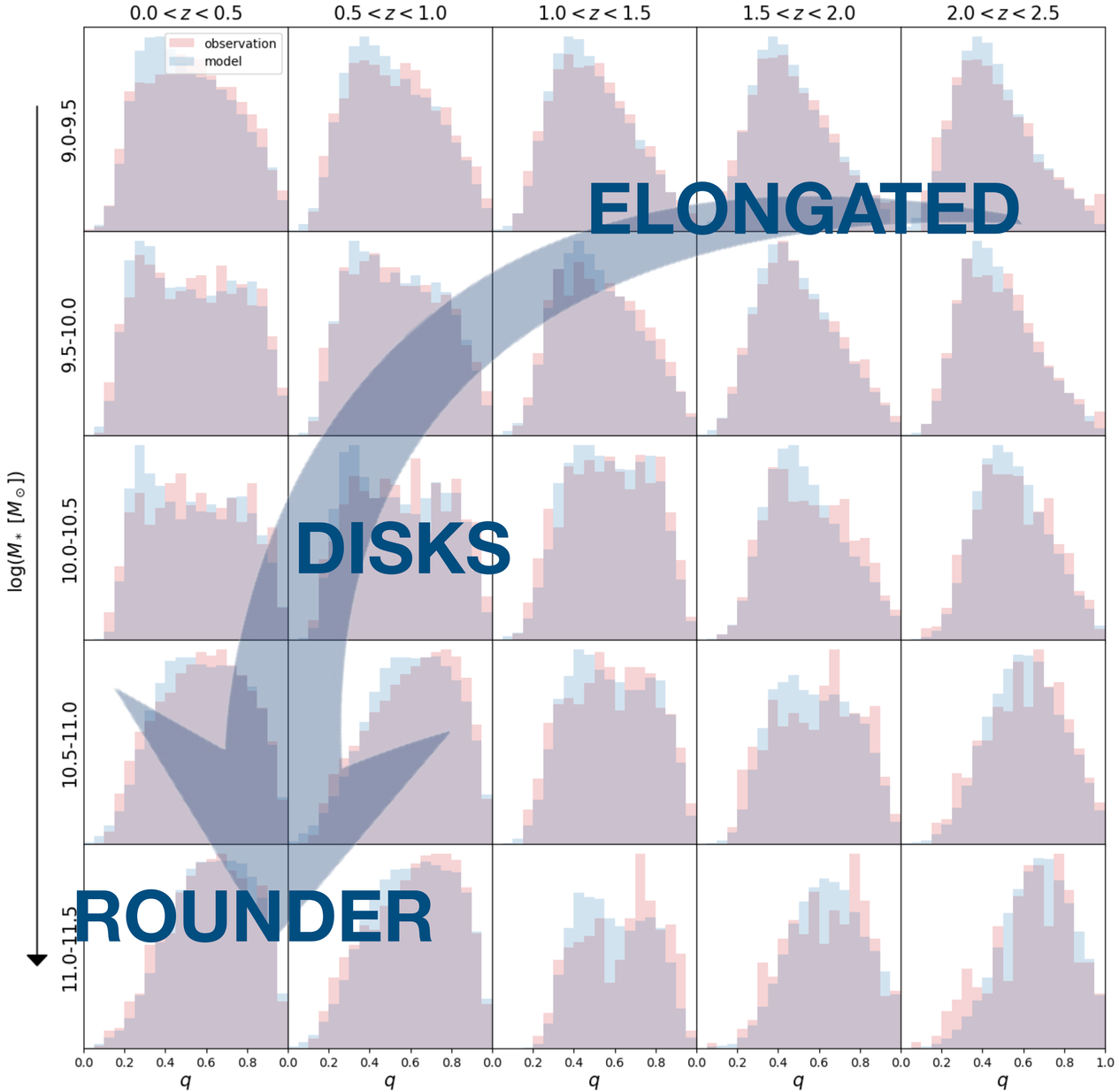

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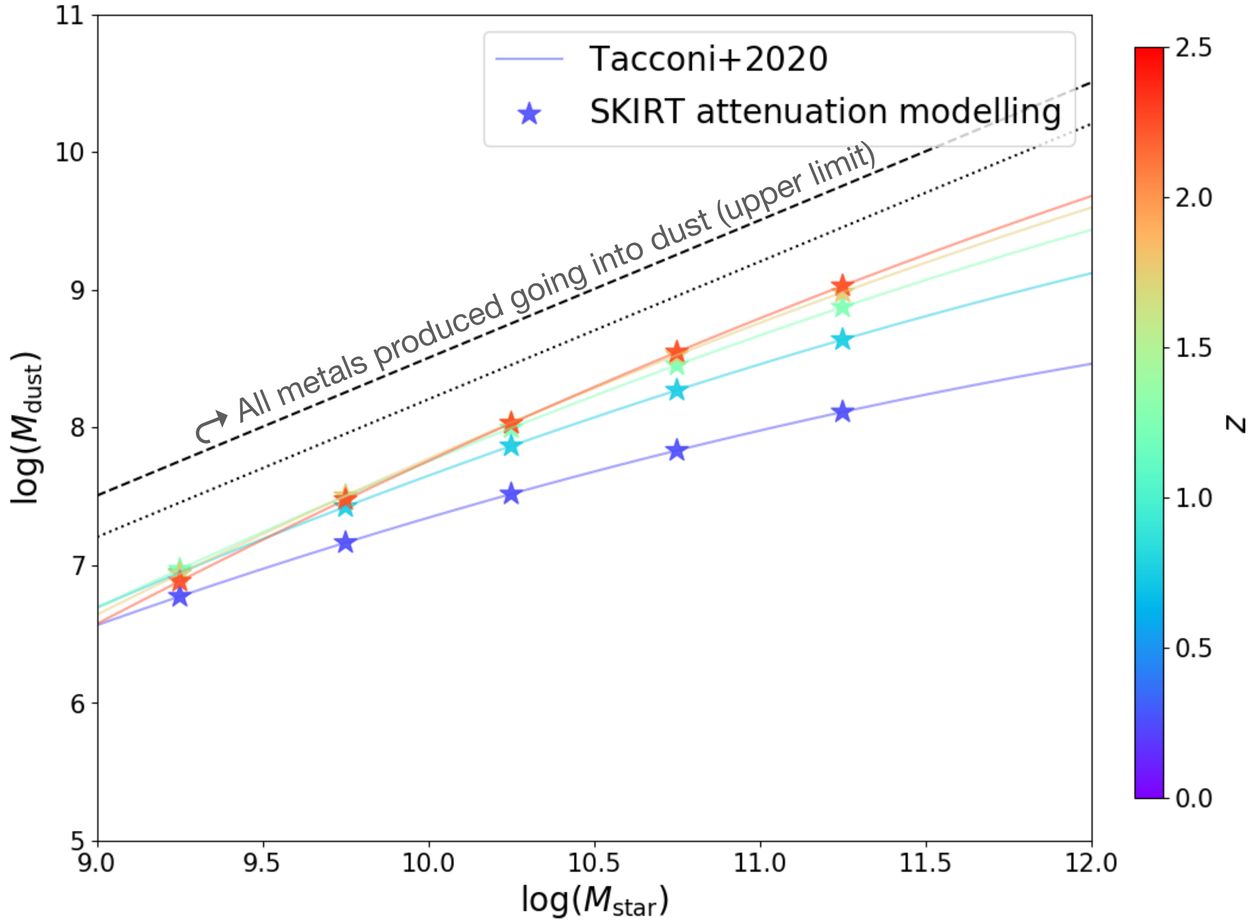

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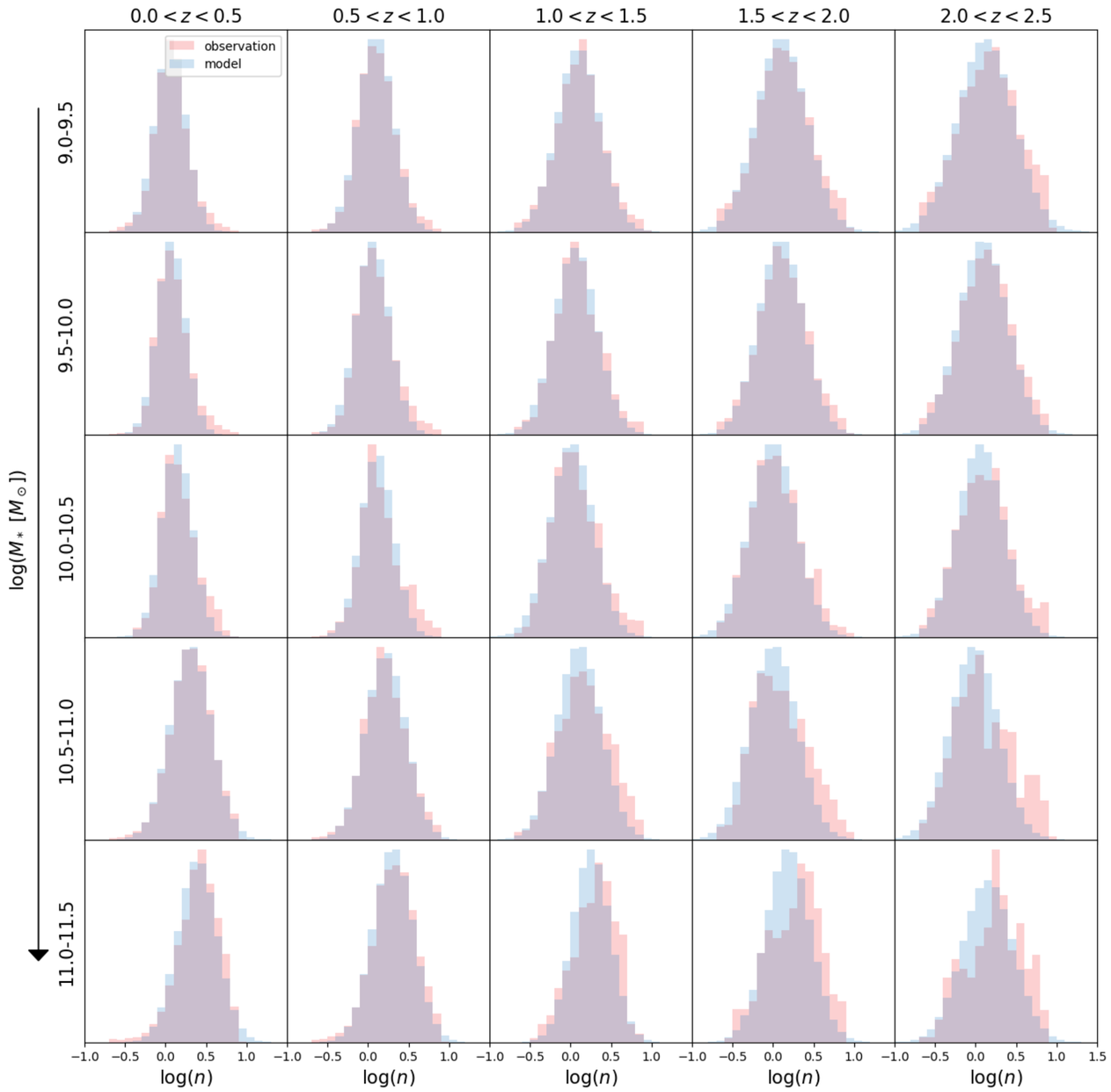

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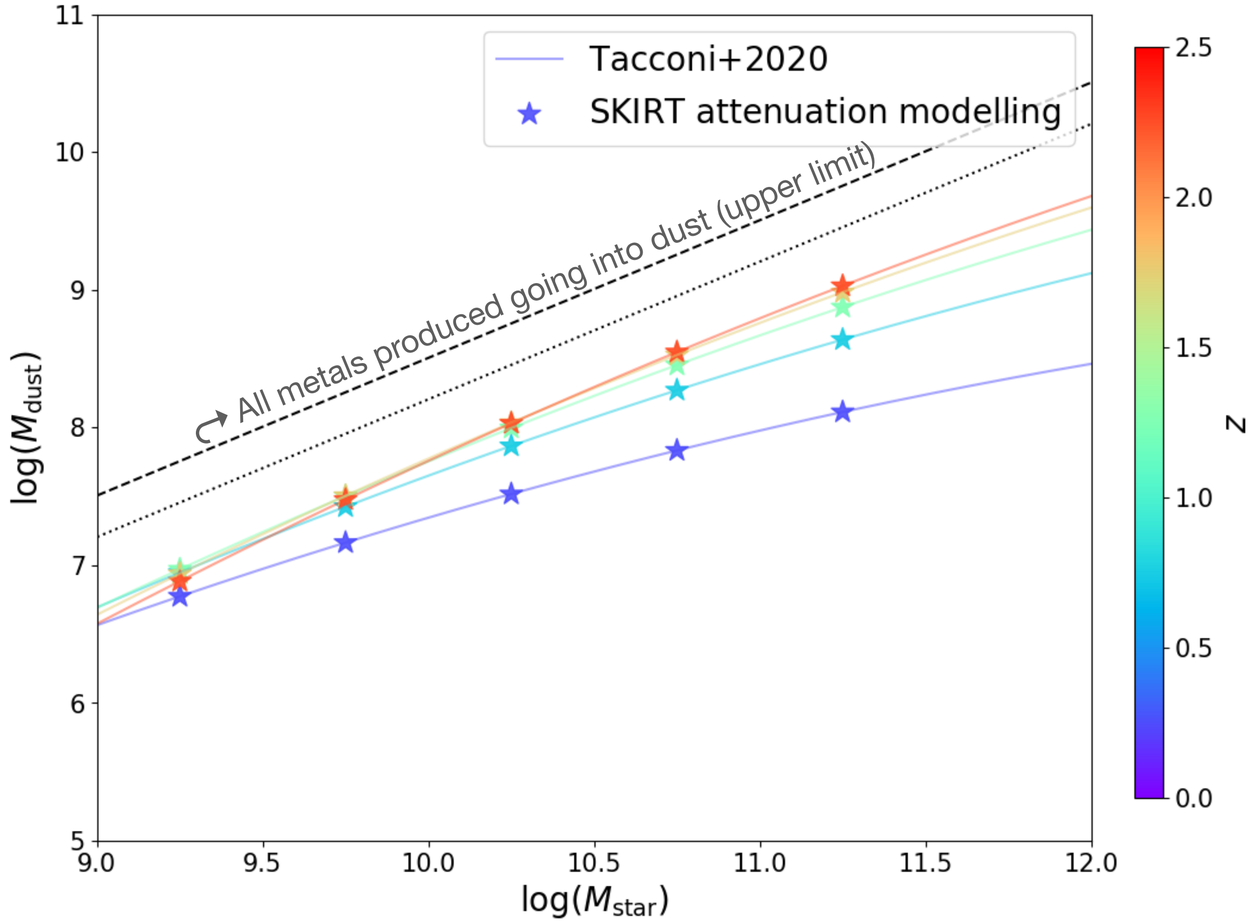

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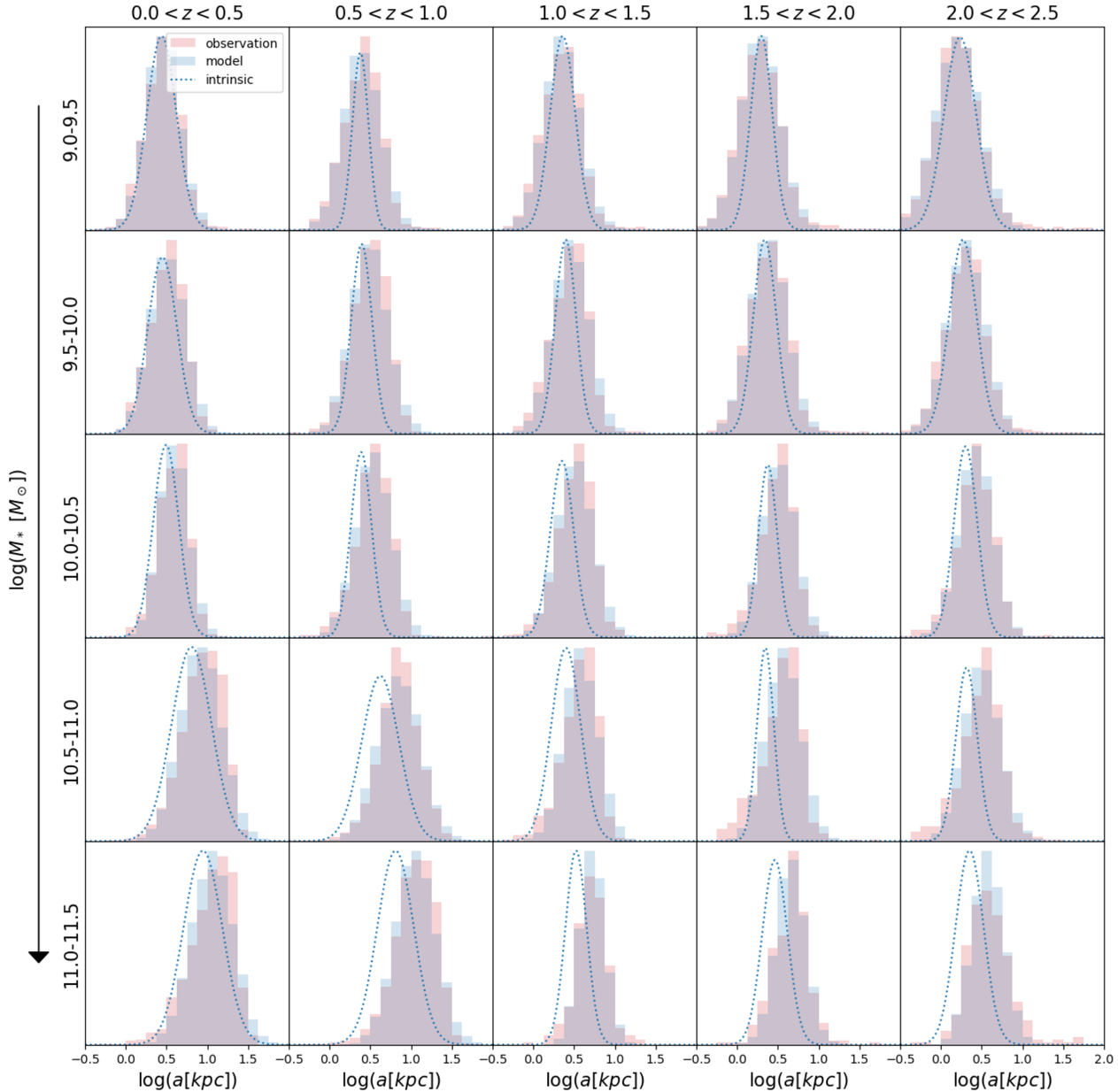

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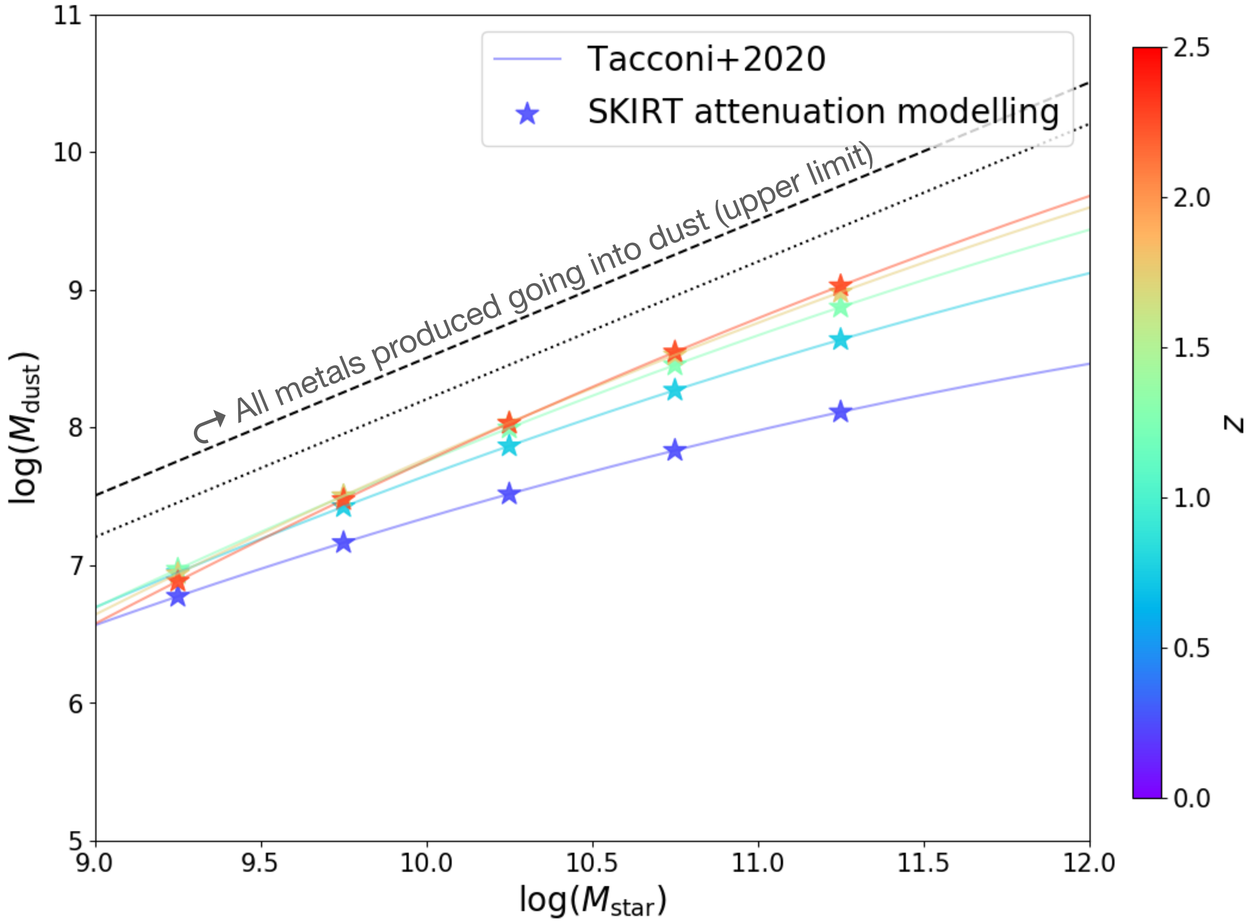

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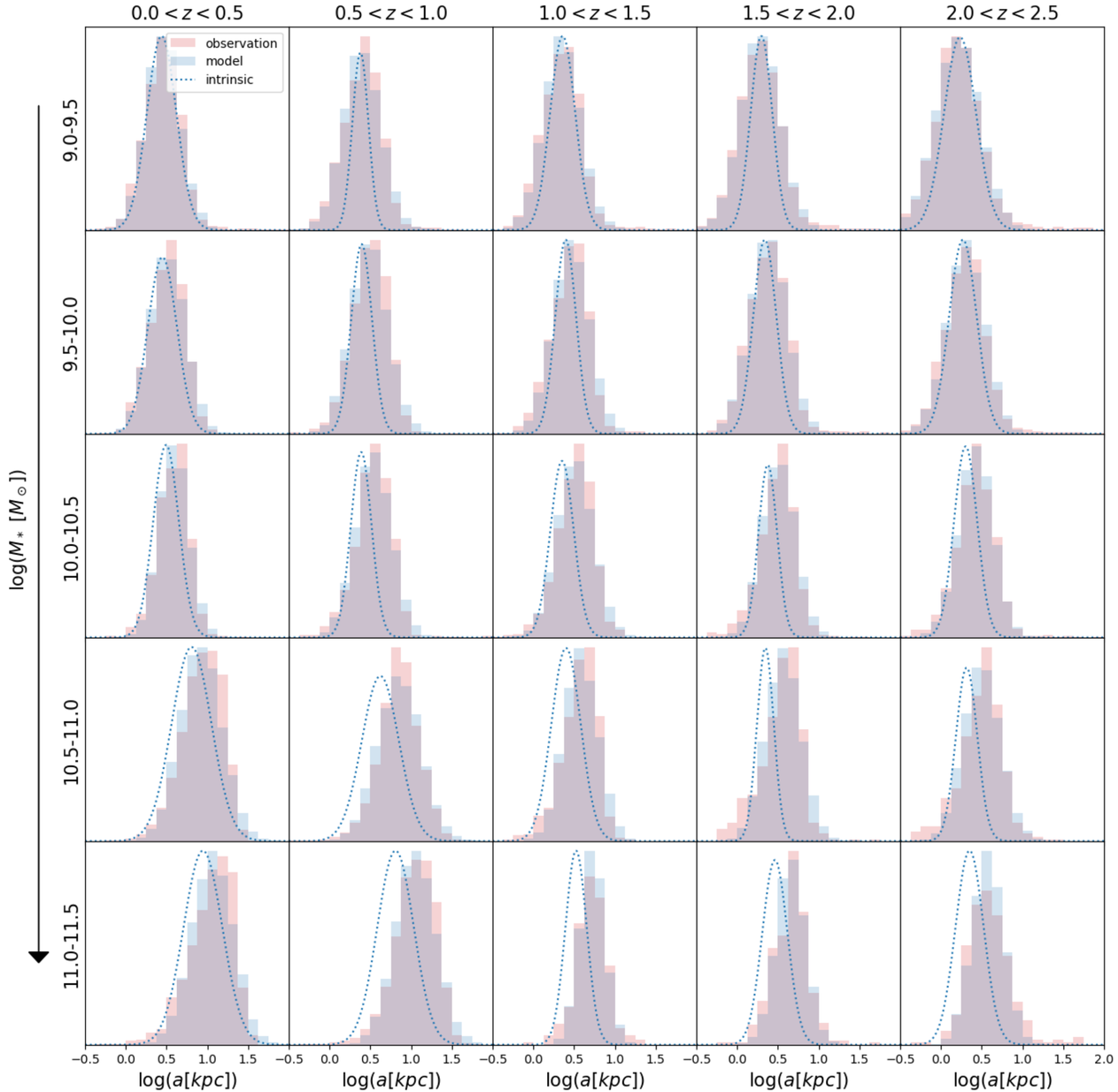
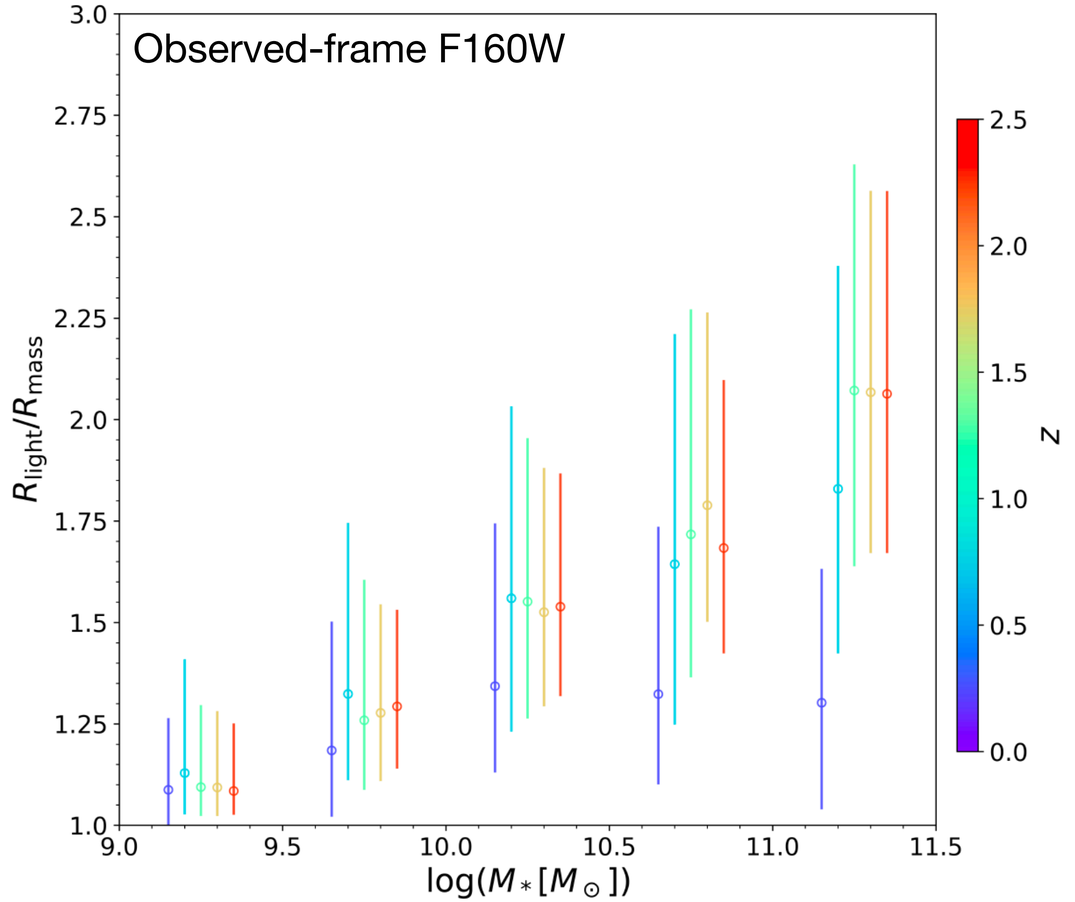


Clumpier dust geometries in higher-z SFGs

Larger half-light than half-mass radii (due to dust)



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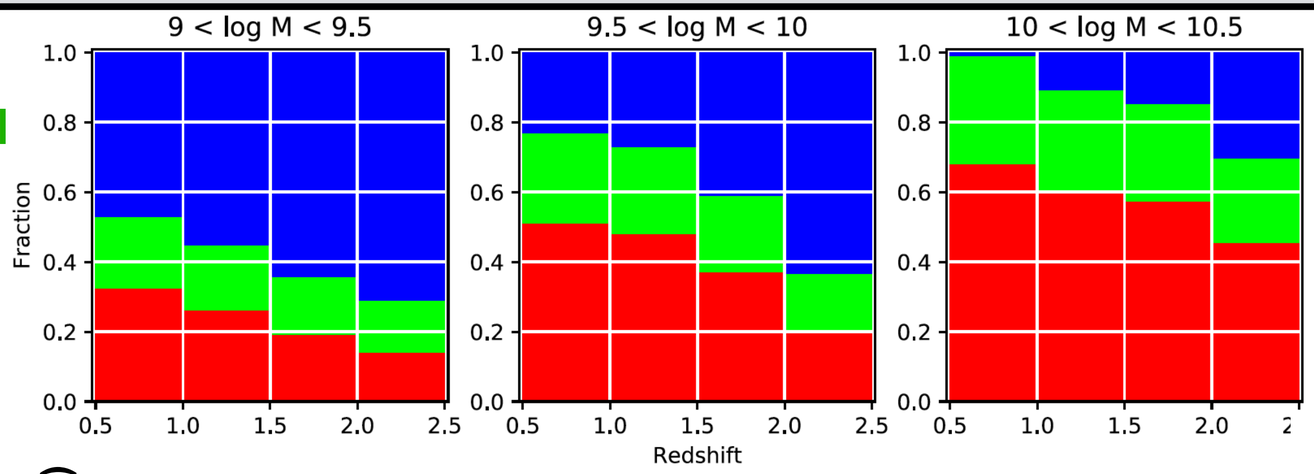
Half-light vs half-mass R_e: also Wuyts+12; Suess+19,22; Popping+22

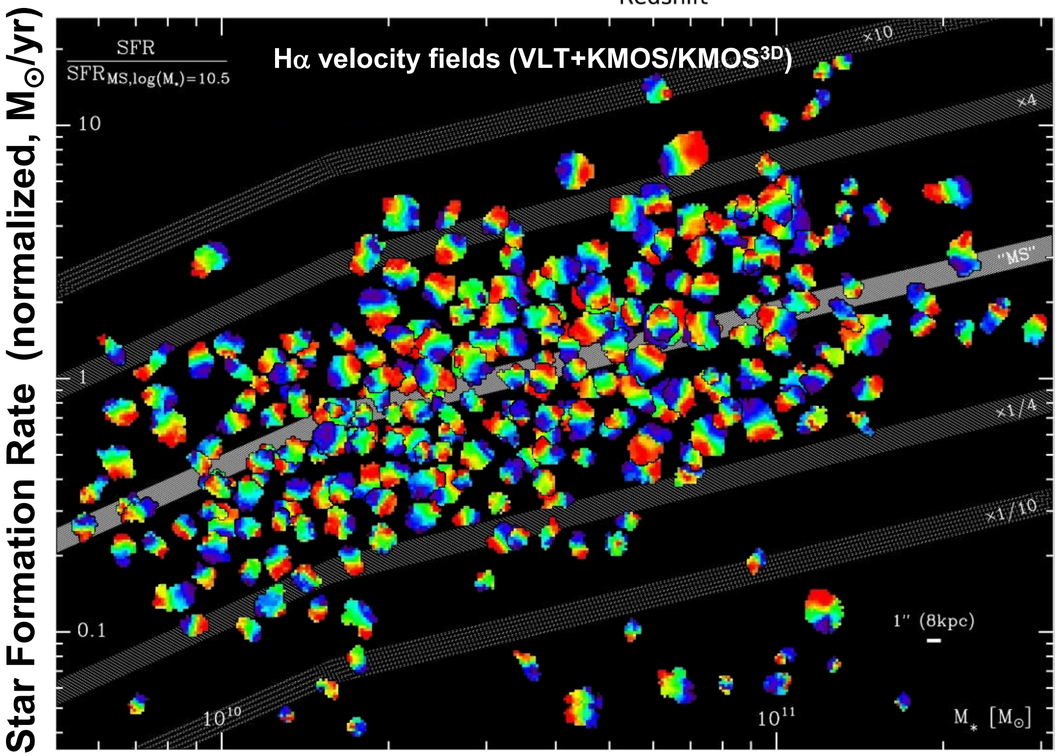
Intrinsic 3D shapes - star-forming galaxies

Elongated
Spheroidal
Disky

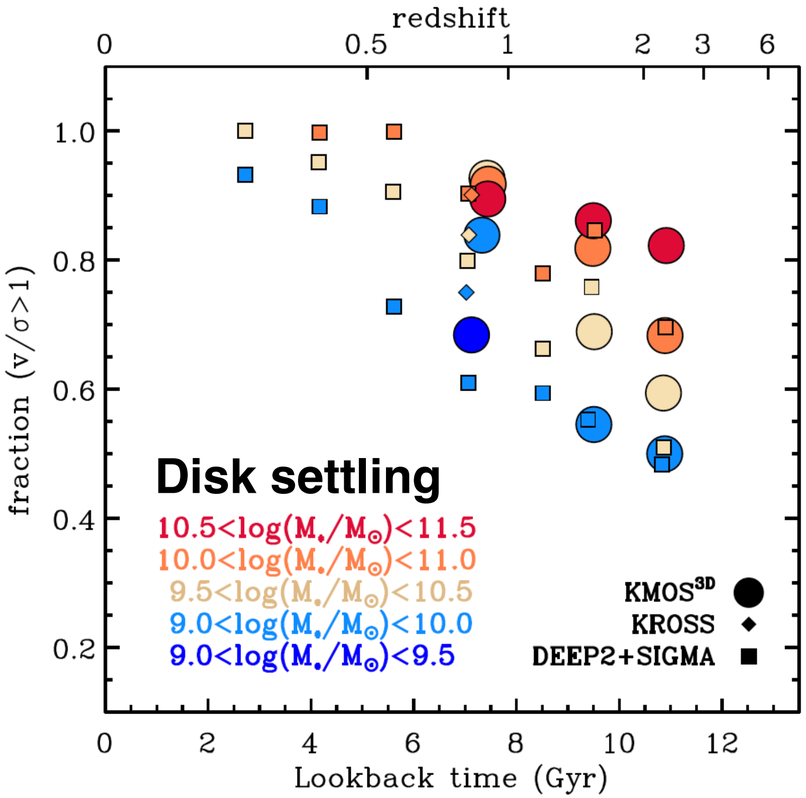


Elongated (prolate) shapes at low-M & high-z

Zhang+2019 **CANDELS**
also Elmegreen+2005; Law+2012; van der Wel+2014

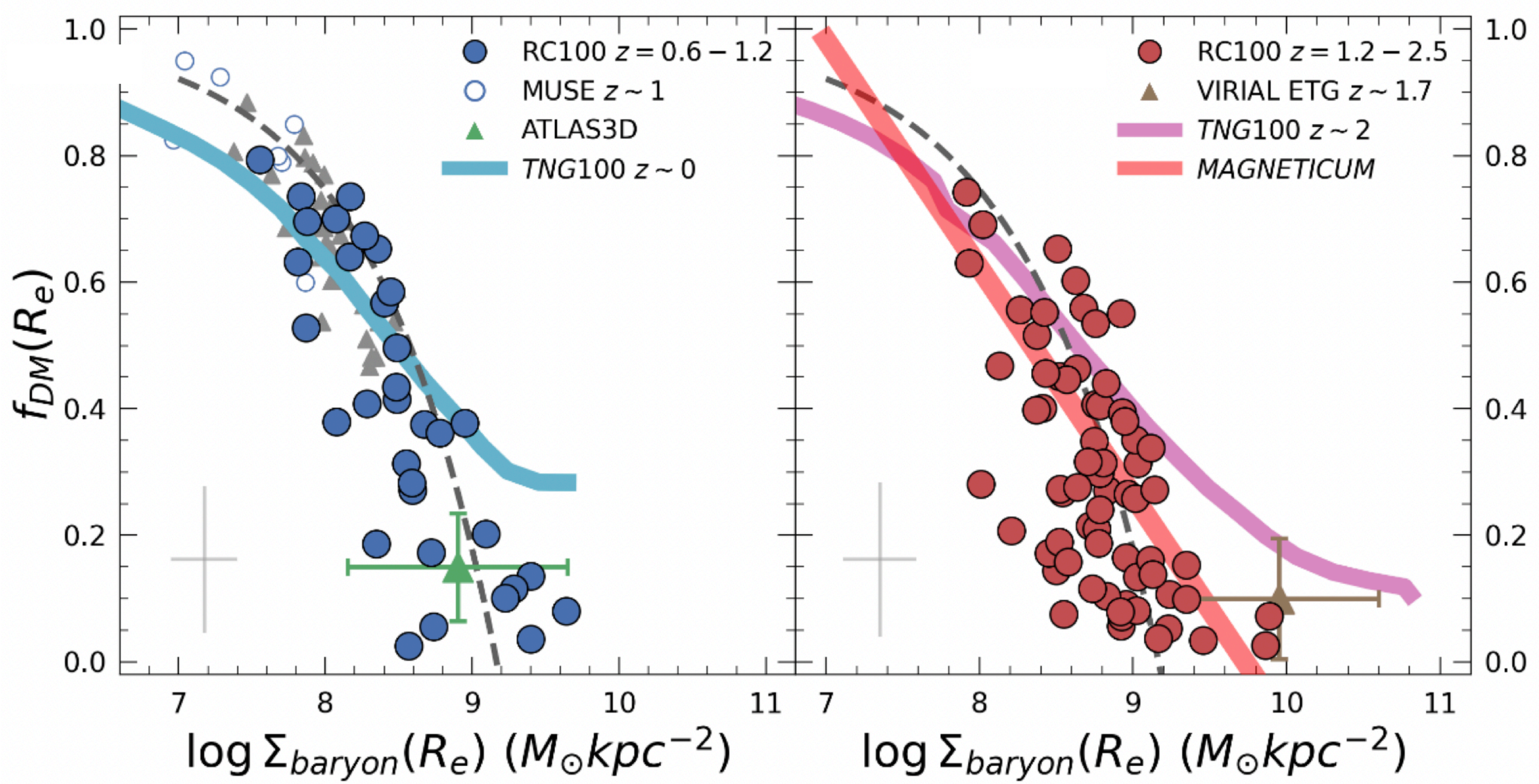


Förster Schreiber & Wuyts 2020



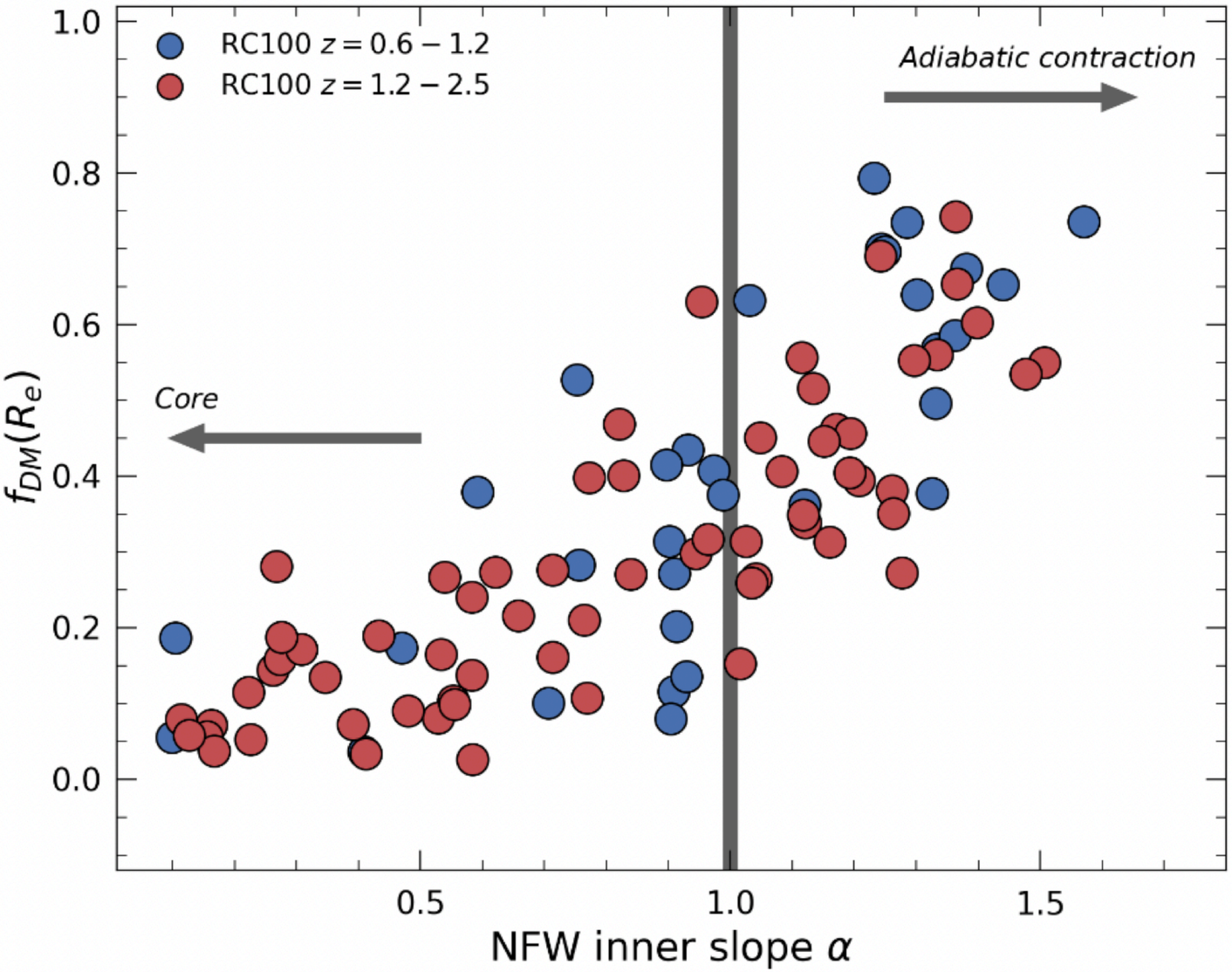
Wisnioski+2019; also Kassin+2012; Simons+2017; Turner+2017; Tiley+2021

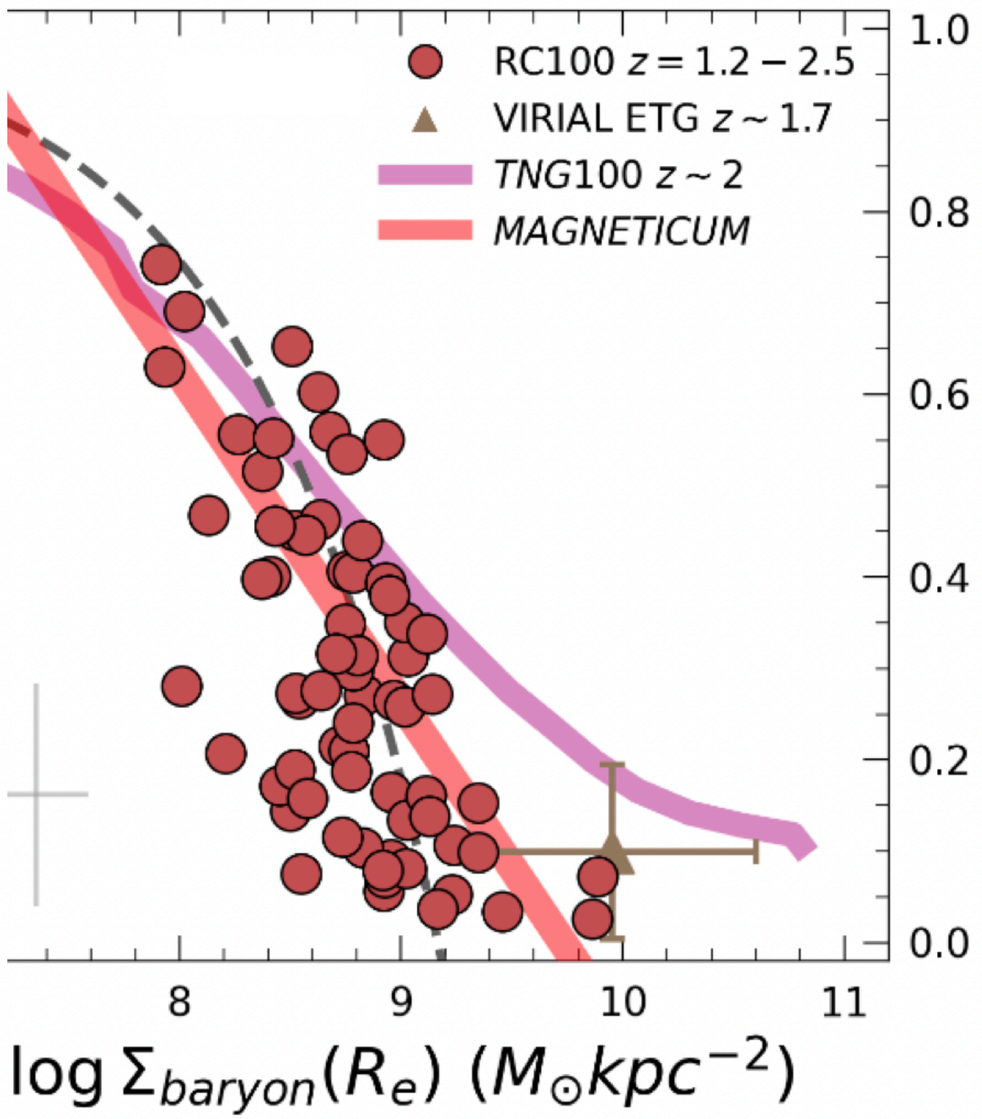
Baryon dominance within R_e for high Σ_{bar} disks



Nestor+2022; also Wuyts+2016; Genzel+2017,2022; Lang+2017; Mendel+2020; Price+2021 (see Bouché+2022 for cores in low-M, DM-dominated galaxies at z~1)
Theory: Lovell+2018; Dekel+2021; Übler+2021 Further observational perspectives: Tiley+2019; Sharma+2021; Lelli+2021

Baryon dominance within R_e for high Σ_{bar} disks





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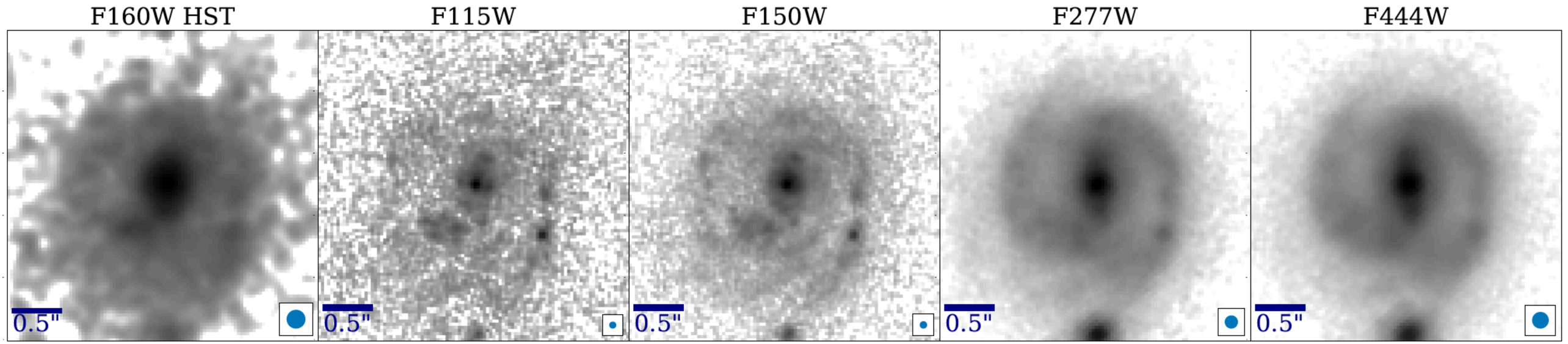
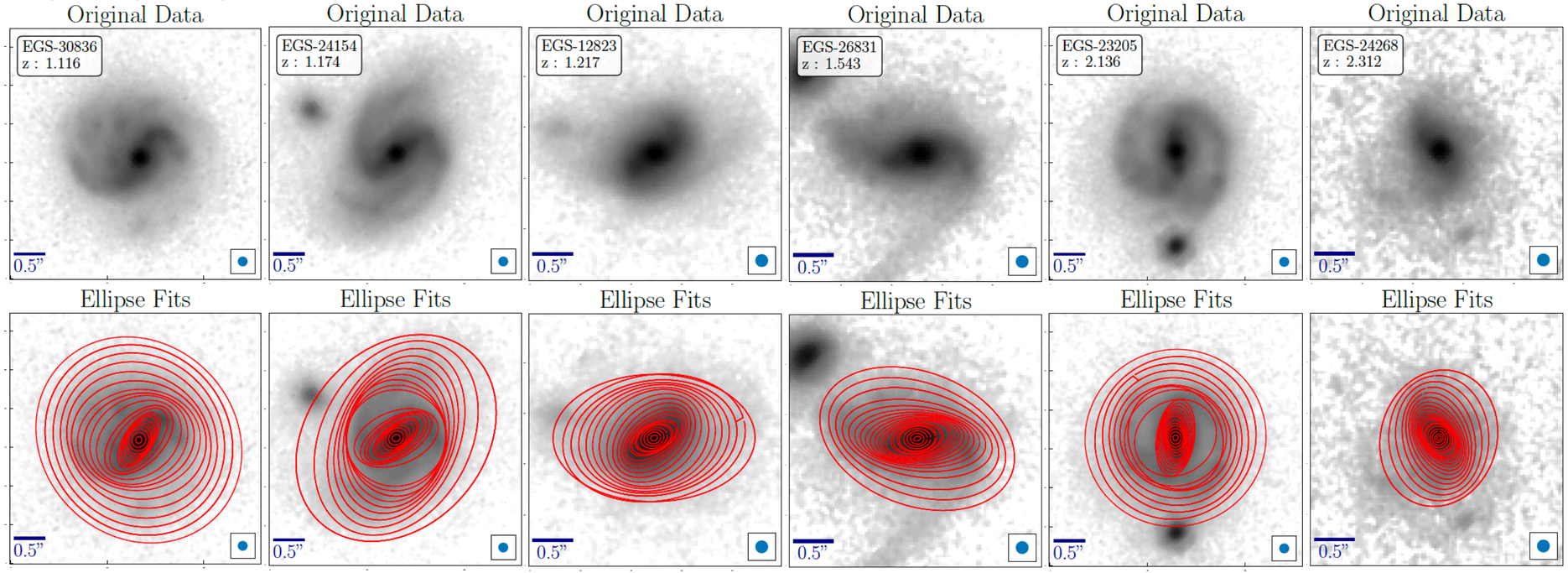
JWST: rest-NIR reveals an early onset of bar formation



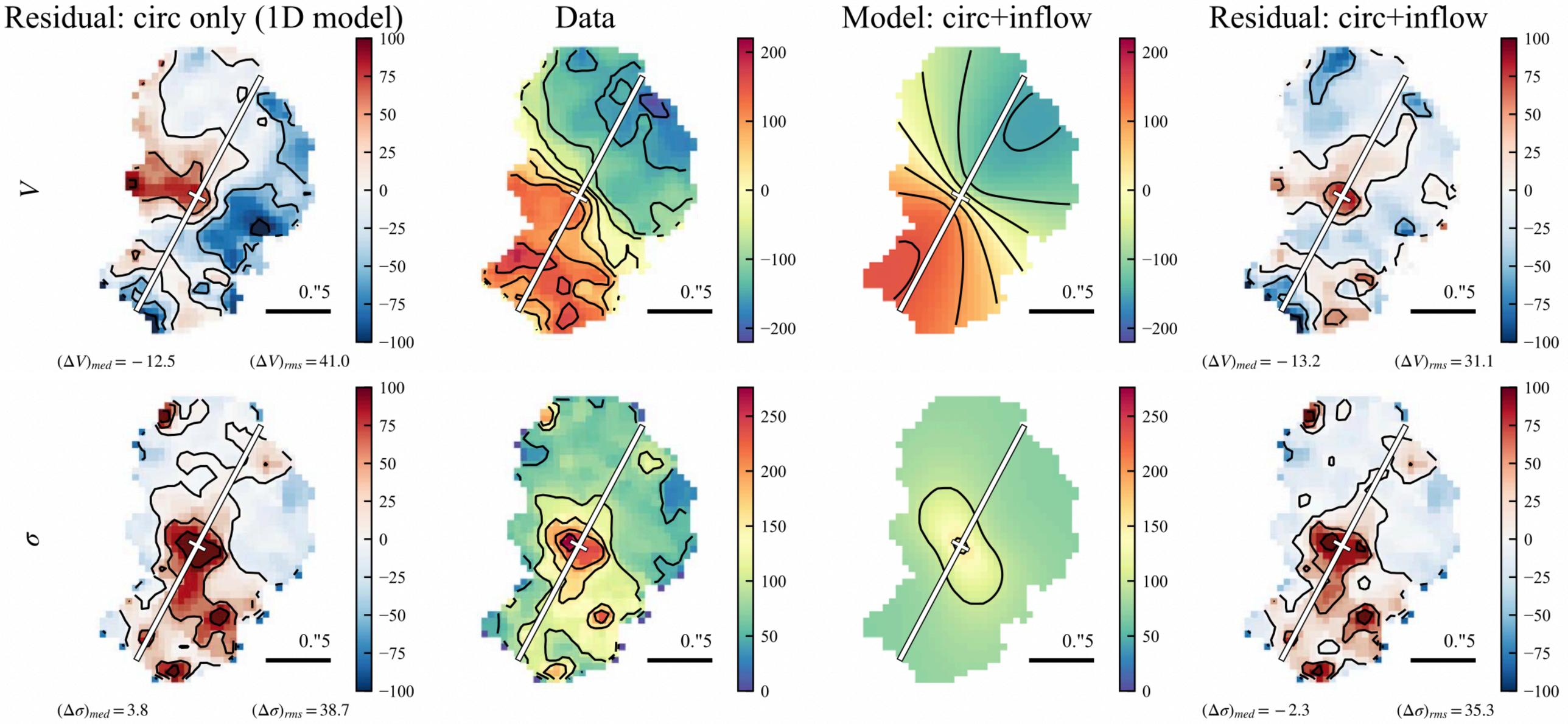
Guo+2022



Cosmic Evolution Early Release Science Survey

CEERS

Kinematic residual maps — signatures of non-circular motions



Price+2021

Conclusions

Quiescent galaxies
Intrinsic 3D shapes

Shapes ~ merger histories

Round in 3D @ log(M) > 11
and/or when n ≳ 4,
yet more in overdensities

These trends hold for z=0-1
z~2 QGs more disky!

Star-forming galaxies
Star & dust geometries

Clumpier dust geometries at high z

Needed to reconcile inclination-dependent attenuation with constraints on M_{dust} from FIR scaling relations.

Based on RT accounting for projected axis ratios, sizes and n_{Sersic} of SFGs

Star-forming galaxies
In-situ evolution

In-situ evolution

Disk settling = f(M_{star}, z)

$f_{DM}(<R_e)$ ↘ as Σ_{bar} ↗
⟹ baryons efficiently condense to centre, whereas inner DM profile cored

Kinematic signatures of radial inflow

Rest-NIR morphologies: bars up to z ~ 2